ciable H_2O, known to act as a catalyst in feldspar diffusion experiments (*17*).

Passive upward fractionation of $^{87}Sr^*$ probably occurred in the Kiglapait intrusion through the agency of rubidium-bearing feldspar-like parcels in the melt, acting as carriers of radiogenic strontium. The probability with which radiogenic strontium was regularly conserved to the residual magma is 0.06 (in other words, 94 percent of the $^{87}Sr^*$ escaped from its carrier and equilibrated with the main magma and contemporary crystals). Such a process can be expected only in dry systems, among which are many layered mafic intrusions (*18*) and mid-ocean ridge basalts (*19*). Some of the poorly understood strontium isotopic variations in such rocks may have arisen from the carrier fractionation mechanism, but the evident inefficiency of the process deserves emphasis: crystallization of 90 percent of the system would increase Sr^0 from 0.7040 only to 0.7051, according to the Kiglapait liquid curve. Somewhat greater efficiency would result from the crystallization of olivine without feldspar, causing a more rapid increase in alkalies than occurred in the Kiglapait magma.

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14. A K_D of 1.0 results in no fractionation, that is, a slope of zero.

$$K_D - 1 = D^{WR/L}_{^{87}Sr} - D^{WR/L}_{^{86}Sr}$$
$$= 1.047269 - 1.047683$$

from the decomposed data for the strontium isotope abundances.
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Asian Dust: Seasonal Transport to the Hawaiian Islands

Abstract. *Analyses of atmospheric particles collected at Mauna Loa Observatory in Hawaii from February 1979 through September 1982 reveal strong influxes of Asian dust in the spring of each year. Concentrations of a typical crustal element, aluminum, are more than an order of magnitude greater between February and June than during the remainder of the year (71 ± 51 versus 6.7 ± 2.3 nanograms per cubic meter). The mass of crustal material transported during the relatively short dust episodes accounts for an average of 80 percent of the total yearly mass of atmospheric particles at 3400 meters on Mauna Loa.*

Transport of vast quantitites of Sahara desert dust eastward across the Atlantic Ocean to Bermuda has been known since the late 1960's (*1, 2*). Strong evidence now exists for transport of large quantities of Asian dust westward across the North Pacific (*3–7*). Mauna Loa Observatory (MLO), at an altitude of 3400 m on Mauna Loa mountain on the island of Hawaii, is an excellent site from which to observe this dust. Bodhaine *et al.* (*3*) observed increases in aerosol light scattering (b_{sp}) at MLO from $\sim 1 \times 10^{-7}$ to $\sim 1 \times 10^{-5}$ m^{-1} each spring since 1974, indicating a huge increase in concentration of particles with diameters in the range 0.1 to 1 μm. The site is far enough away from Kilauea volcano that the wind patterns usually do not carry volcanic emissions to the observatory. Other researchers have also used MLO to observe these dust episodes (*5, 7*).

There has been a need for long-term monitoring of these dust events as well as the normal nondust conditions to establish a baseline of aerosol mass and detailed composition in the Northern Hemisphere at a remote site (*3, 8*). As in all studies of aerosol composition, care must be taken to eliminate contamination of samples by locally produced aerosols. Concentrations of major elements are important in categorizing an aerosol's composition as marine, crustal, or anthropogenic. With the addition of trace elements, one should be able to further categorize sources. Trace elements may discriminate between possible sources of dust—for instance, between arid regions (sedimentary material) and Hawaii (basalt). This report presents results from a 4-year study of particle composition at MLO.

The 3400-m altitude of MLO places it well above the mean trade wind inversion layer height of 1800 m (*9*). The inversion greatly restricts mixing of the free troposphere with air below the inversion (*10, 11*). Concentrations of marine particles, which can mask analysis for many trace elements at sea-level collection sites, are reduced at MLO. Continental crustal material is suppressed by the large distances to North America (3800 km) and Asia (more than 6000 km to Japan). For such crustal material to reach Hawaii, large quantities must be dispersed into the free troposphere with proper meterological conditions for long-range transport, as apparently happens during the Asian dust events (*5, 6*). Locally derived crustal material is a possible source of particles at MLO, but trace elemental analyses can be used to identify it. There are few sources of anthropogenic emissions on Hawaii, as no people live near MLO and few vehicles come to it.

Convectively induced mountain winds normally occur in a diurnal upslope-downslope pattern (*12*). Particles collected during daytime upslope flow should represent air from just above or below the trade wind inversion, depending on the altitude and strength of the inversion. This air could contain significant concentrations of local aerosols from weathered basalt, marine sources, or anthropogenic sources which have mixed through the inversion layer. By contrast, nighttime downslope winds bring air from above Mauna Loa to MLO. Such air has minimal contact with the mountain slopes and thus little opportunity to pick up local particles. Aerosols borne by these downslope winds should be representative of midtropospheric air in this region of the Pacific. To sample these winds at MLO, we constructed a digital sector analyzer-controller with help of

the National Bureau of Standards. Since 29 April 1980 this controller has been used to differentiate between upslope, downslope, and synoptic winds on the basis of wind direction, wind speed, and time of day. It also monitors condensation nuclei count (CNC) [from the National Oceanic and Atmospheric Administration (NOAA) General Electric CNC] and light scattering (b_{scat}) at 550 nm [from the NOAA multiwavelength integrating nephelometer (*3*)]. Under nonsampling conditions (which include storms and calms where winds are < 1 m/sec), a third sampler is activated. The system thus gives a constant record of the aerosols at MLO on three samples: one sample representing particles collected under downslope conditions; another representing upslope conditions; and the third, collected whenever the other samplers are both off, representing high synoptic activity, calms, and possible contamination. The CNC detects such contamination and stops the upslope or downslope samplers when the count is > 600 nuclei per cubic centimeter. Samples are taken weekly, so that each sample typically covers seven upslope or downslope periods.

Samples were collected at MLO from February 1979 through September 1982, except for 2 months during the summer of 1979. In April 1980, the sector controller described above replaced a time-of-day system previously used. Samples were collected on Nuclepore filters 110 mm in diameter and 0.4 μm in pore diameter. Polyethylene filter holders are located on a 10-m tower with pumps located in a shelter at ground level. Filters are changed by NOAA personnel in a clean hood at MLO or sent to the University of Maryland to be changed in a clean room with filter cartridges. At Maryland, filters are analyzed by instrumental neutron activation analysis (INAA) by a procedure similar to that reported by Germani *et al.* (*13*). Up to 35 elements are measured in most samples. The detailed chemical composition of the Asian dust is discussed elsewhere (*14*).

Aluminum is often used to indicate crustal dust, as it is measured accurately by INAA and its concentrations in many soils and rocks are known. A unique characteristic of the Hawaiian basalt, its Ti/Th ratio, can be used to determine the extent to which locally derived crustal material contributes to observed aluminum concentrations. Analyses of basalt collected at MLO and of U.S. Geological Survey standard reference Hawaiian basalt (*15*) reveal that Hawaiian lava is enriched in titanium and depleted in thorium relative to the Taylor crustal average and sedimentary rocks in general (*16*). The Ti/Th ratio is 16,300 in Hawaiian basalt and 590 in the Taylor crustal pattern. The average ratio for 1979 to 1981 downslope samples is 580 ± 200. Agreement between the downslope ratio and the Taylor ratio suggests that relatively little local crustal material is borne by downslope winds at MLO. Upslope samples exhibit slightly elevated Ti/Th ratios during the cleaner months of the year (July through January), indicating that they pick up a significant amount of local crustal particles. Downslope samples are thus preferred for the study of Asian dust because they are nearly unaffected by locally generated particles.

Downslope aluminum concentrations for the entire sampling period are shown in Fig. 1. Note the large influx of crustal material during the spring of each year. Both upslope and downslope data show this effect for all crustal elements analyzed during each year. Increases begin in February, peak in late April to early May, and last through June. During nondust periods (July to January) aluminum concentrations average 6.7 ng/m^3, whereas from February to June the average is 71 ng/m^3, with some weekly samples having concentrations > 200 ng/m^3. Using Taylor's value of 8.23 percent aluminum in crustal material, we estimate total mass loading of crustal material to be 860 ± 620 ng/m^3 during the dust period and 81 ± 28 ng/m^3 during the remaining 7 months. The mass of marine and dust components for the period of this study are given in Table 1. Integration of excess crustal loadings during the Asian dust periods shows that the dust increases the yearly average loading of crustal dust from 81 to 406 ng/m^3, a fivefold measure. Loadings from February to June average more than ten times those of other months.

To place the magnitude of the crustal dust in perspective, consider the concentrations of marine components at MLO. Sodium has two major sources at MLO: crustal material and marine aerosols. Crustal sodium can be estimated from average crustal sodium and aluminum concentrations

$$Na_s = Na_T - [Al_T(Na/Al)_c]$$

where Na_s is sea sodium, Na_T and Al_T are total concentrations in a sample, and $(Na/Al)_c$ is the crustal ratio of these elements. Values of downslope sea sodium are plotted in Fig. 1. Increases in concentration of marine aerosols as indi-

Table 1. Downslope concentrations of crustal and marine components, and calculated crustal and marine mass concentrations observed in dust and nondust periods of each year.

Material	Concentration (ng/m^3)				
	Total aluminum	Total sodium	Sea sodium	Mass marine	Mass crustal
Dust 1979	115 ± 68	31 ± 22	8.6 ± 7.7	27 ± 24	1400 ± 830
Dust 1980	57 ± 40	21 ± 11	7.7 ± 6.3	24 ± 19	690 ± 490
Dust 1981	61 ± 33	29 ± 3	15.3 ± 8.7	46 ± 27	740 ± 400
Dust 1982	46 ± 34	19 ± 6	6.5 ± 5.4	20 ± 17	560 ± 410
Average dust	71 ± 51	25 ± 13	9.7 ± 7.5	30 ± 23	860 ± 620
Nondust 1979	6.4 ± 2.0	17 ± 9.8	16.5 ± 9.7	51 ± 30	78 ± 24
Nondust 1980	8.2 ± 2.2	9.0 ± 4.7	7.3 ± 5.4	23 ± 17	100 ± 27
Nondust 1981	6.2 ± 2.5	9.6 ± 11	8.4 ± 11.3	26 ± 35	75 ± 30
Nondust 1982	5.3 ± 4.0	6.9 ± 6.1	5.6 ± 5.5	17 ± 17	64 ± 49
Average nondust	6.7 ± 2.3	11.0 ± 9.2	9.5 ± 9.2	29 ± 28	81 ± 28

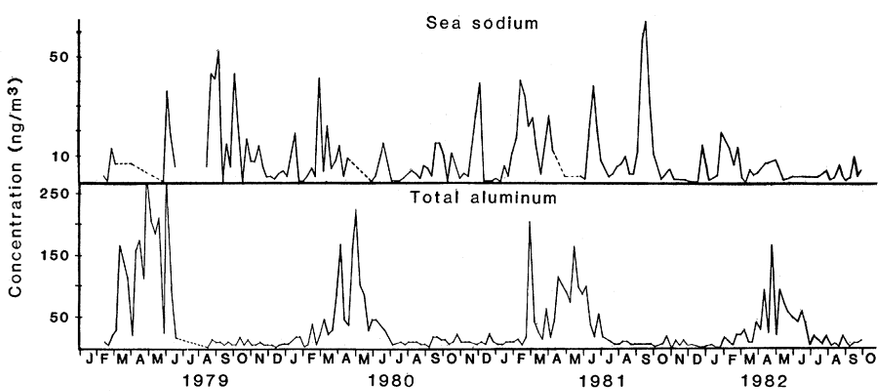

Fig. 1. Weekly downslope aluminum and marine sodium (as excess sodium) concentrations for high-volume aerosol collections at MLO.

cated by excess sodium generally correspond with periods of high storm activity as determined from NOAA meteorological records (*17*). Apparently, storm activity creates enough tropospheric turbulence to transport marine aerosols to the midtroposphere. Periods of high sea sodium preceded occurrences of the dust in 1980 and 1981; however, the sea sodium peaks are lower in 1982. This suggest that fewer strong storms occurred throughout the Pacific basin and Asia, resulting in less dust being transported to Hawaii in 1982. Also, changes in air mass trajectories may be responsible for the decrease in 1982.

Asian dust appears to come in waves and the concentration peaks are fairly symmetrical, probably because of meteorological conditions where the dust originated. Such processes would tend to transport dust in waves, which could have a duration of several days as observed in other, shorter term studies at MLO (*5, 7*). The actual peak concentrations of dust could thus be much higher than the weekly average concentrations of this study which appear in Fig. 1.

Upslope samples collected during 1979 and 1980 support the downslope filter results (*14*). During cleaner months, crustal concentrations in these samples are about three times higher than in downslope samples (*14*) and to some extent appear to represent local basaltic particles, as noted above. Yet when the dust occurs crustal material is often found in higher concentrations in downslope samples. This suggests that the Asian dust is in higher concentration above the altitude of MLO, which supports Shaw's observation (*5*) that the dust occurred in a layer above the altitude of MLO; thus, downslope wind would bring dust from closer to the center of this dust layer to MLO than would upslope winds. Prospero *et al.* (*1*) found similar results in that Saharan dust became well mixed throughout the troposphere above the marine boundary layer, with some more stratified layers in existence after transport over several thousand kilometers. A similar situation may occur in this case.

In conclusion, the Asian dust events in the Pacific occur consistently in the spring, generally peaking in late April and early May. These events account for most of the crustal material, which amounts to about five times more yearly crustal mass then would be present if the events did not occur. This large influx may be a significant contribution to sedimentation rates in the Pacific, as suggested by others (*4, 18*).

The dust events observed in this study are consistent with results of other studies at MLO and in the Pacific. Bodhaine *et al.* (*3*) observed maxima in b_{sp} during the spring of each year from 1974 to 1980. The 1979 and 1980 b_{sp} data contain increases that correspond to peaks in Fig. 1 and are obviously due to Asian dust. Part of the Sea-Air Exchange (SEAREX) program involves study of Asian dust events in the Pacific (*18*); results of 1981 sampling on Oahu show six peaks that are very similar in concentration and time of occurrence to our results.

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Argonne Intense Pulsed Neutron Source Used to Solve the Molecular Structure of a Novel Organometallic Complex

Abstract. *The single-crystal structure of $Mn(CO)_3(C_7H_{11})$ is the first to be solved by direct methods based on time-of-flight neutron diffraction data obtained at the Argonne Intense Pulsed Neutron Source. The molecule contains an unusual three-center, two-electron manganese-hydrogen-carbon interaction.*

The application of single-crystal neutron diffraction techniques to chemical problems that have a bearing on C–H bond activation is a relatively new and potentially fruitful area of research. Although the pioneering structural work (*1*) was done by x-ray diffraction because of the small size of the crystals, neutron diffraction is preferable since it provides accurate hydrogen atom positional and thermal parameters without the systematic C–H bond shortening obtained with x-ray diffraction. Using neutron diffraction, we have characterized a number of molecules with elongated C–H bonds due to "activation" of the bond by a nearby metal (*2, 3*). These studies provide bonding models that can improve our understanding of chemical reactivity and catalytic processes (*4*). We now report the neutron diffraction structure of methylcyclohexenylmanganese tricarbonyl, $Mn(CO)_3(C_7H_{11})$; the key feature of this structure is the intramolecular interaction of the manganese atom with an aliphatic C–H bond.

To our knowledge, this is the first single-crystal structure to be independently solved on the basis of time-of-flight (TOF) neutron data from a pulsed neutron source. The data were obtained at the Argonne Intense Pulsed Neutron Source (IPNS) (*5*) with a new single-crystal instrument based on the TOF Laue technique (*6*). We believe these results represent a seminal achievement in the advancement of an important new structure determination method.

The ability to obtain neutron diffraction data is often limited by the low flux available from neutron sources. Furthermore, with conventional instruments only a small percentage of the available neutrons are selected with a monochromator, and the remainder are wasted. Neutrons are produced at IPNS by a spallation process in which high-energy (500-MeV) protons are accelerated into a uranium target in small bursts at 30 times per second to generate very high peak neutron fluxes (*5*). Because of the pulsed nature of the source, nearly the entire spectrum of moderated neutrons is used by application of TOF techniques to de-