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LETTERS

Antarctic Environmental Concerns

After two news items about Antarctic science appeared in *Science* (News & Comment, 17 Jan., p. 276; Briefing, 24 Jan., p. 406), it occurred to me that readers might be interested in an elaboration of what the National Science Foundation (NSF) is doing to clean up the Antarctic environment and to minimize pollution.

Antarctica's principal use is as a research laboratory. Last year 26 nations signed a protocol to strengthen existing Antarctic Treaty measures to protect the environment. Joseph Palca's 17 January article suggests that the new protocol will make conducting research more difficult. We believe it is making our program more accountable. The U.S. Antarctic Program, managed by the NSF, has not waited for the protocol to enter into force; it is complying as quickly as possible. Research stations, some of which have supported science for 35 years, are being cleaned up, and improved methods of waste management have been put into practice.

The NSF's $30-million Antarctic cleanup program, begun in 1990, provides for improvements in many areas, including specialized activities such as identification, packaging, and removal of hazardous waste to facilities outside Antarctica for proper disposal. For some two-thirds of the U.S. Antarctic Program, McMurdo—the largest station in Antarctica—is the center for logistics and for waste management. All the waste from dozens of outlying research camps, plus solid and hazardous waste from America's year-round station at the geographic South Pole, is handled through McMurdo. A smaller U.S. operation near the Antarctic Peninsula is centered at Palmer, a research station long admired as exemplary in its waste handling.

Substantial improvements began around 1980, when the NSF issued an environmental impact statement for the U.S. Antarctic Program (*1*). McMurdo's open shoreside dump was replaced with a fenced waste processing area away from the sea, at a site called Fortress Rocks, and a general cleanup was commenced. As might be expected, there were some problems. For example, the Fortress Rocks site had to be closed last year when materials containing asbestos were found. The asbestos-laden material as well as the total accumulation of all other surface debris were removed from the site during the 1991–1992 austral summer. In one case, noted in the 24 January Briefing, old, unstable laboratory chemicals found in storage were safely destroyed at a remote location on the Ross Ice Shelf.

Most wastes and recyclables are sorted and saved for removal on the cargo ship that arrives with resupplies once a year in midsummer. This year the ship retrograded 2581 tons of sorted waste and recyclable materials along with carefully identified hazardous waste for approved disposal outside Antarctica. An incinerator installed at McMurdo this season is used to burn kitchen waste and food-contaminated packaging; the ash is removed from Antarctica. Formerly, these wastes were burned in the open at Fortress Rocks, and the ash was left as landfill. Other improvements have included replacing fuel bladders with steel tanks; replacing old, short-length fuel hoses with new, long-length sections that have "dry-break" connections; and the staging of control and containment equipment ready to recover spilled fuel.

The NSF practices diligent control of environmental aspects of its activities in Antarctica. Research proposals are not considered for funding until the investigator addresses environmental concerns. Construction and disposal projects do not begin until potential environmental impacts have been considered. The NSF's Antarctic personnel manual describes each person's environmental responsibilities and notes legal penalties for noncompliance. McMurdo's weekly newspaper carries stories on environmental successes and lessons learned from the infrequent but inevitable mishaps that occur. Books and films prepared by the NSF are shown to each participant.

The responsibilities of the NSF extend beyond its own program. Tour companies are provided educational materials regarding Antarctic environmental protection, and NSF observers are placed aboard tour ships to monitor compliance.

Investigators are studying both the remnant environmental impacts of past practices and the effect of today's improved procedures. Recent investigations have shown that, over the years, activities at McMurdo have polluted the bottom of Winter Quarters Bay, a roughly triangular embayment about 600 feet on a side. They also have shown that, immediately outside the bay, levels of pollutants are two orders of magnitude lower, and sites half a mile away are not polluted (*2*, *3*).

The NSF is fully committed to protecting the environment of Antarctica. It complies with all applicable regulations. In Antarctica, as in the United States, less careful past procedures have come home to roost. We are cleaning up vigorously with support from the Administration and Congress.

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1. *U.S. Antarctic Program Final Environmental Impact Statement* (National Science Foundation, Washington, DC, June 1980); *Final Supplemental Environmental Impact Statement for the United States Antarctic Program* (National Science Foundation, Washington, DC, October 1991).
2. H. S. Lenihan, J. S. Oliver, J. M. Oakden, M. D. Stephenson, *Mar. Pollut. Bull.* 21, 422 (1990).
3. R. W. Risebrough, B. W. De Lappe, C. Younghans-Haugh, *ibid.*, p. 523.

Palca's 17 January article "Poles apart, science thrives on thin ice" gives the impression that environmental constraints in the Antarctic have now become so strict that they may even threaten Antarctic science. Unfortunately, in our experience the opposite is proving to be the case: the environmental constraints imposed in the Antarctic are proving inadequate to protect the science we are conducting at the Arrival Heights Site of Special Scientific Interest (SSSI). Furthermore, the threat to our experiments involves an apparent violation of the Antarctic Treaty by a private company. If it is allowed to stand, it could lead to a severe weakening of the protection for all the SSSI's and Specially Protected Areas in the Antarctic, which include unique penguin and seal colonies, unusual fossil deposits, and areas that are being used for long-term monitoring studies of Antarctic flora and fauna.

The Arrival Heights SSSI was the second to be established in the Antarctic, and it is the only one devoted to the physical sciences. Its purpose was to provide an area uncontaminated as far as possible by man-made radio interference, and as a result its management plan specifies that "no RF [radio frequency] transmitting equipment other than low power transceivers for local essential communication may be installed within this site. Every precaution should be taken to ensure that electrical equipment is adequately suppressed and correctly installed to keep man-made electrical noise to a minimum." With the assurance provided by this plan we installed passive radio measurement systems in the Arrival Heights SSSI.

This last austral summer, without consulting with the U.S. scientists operating at Arrival Heights, the Telecom Corporation of New Zealand installed a satellite earth station (SES) on First Crater, which delimits the southern boundary of the Arrival Heights SSSI. Because the SES uses a radio transmitter that is located within the SSSI and which broadcasts directly over the site (at a low angle of elevation), both the construction and the broadcasts appear to be in clear violation of the Antarctic Treaty. It is our understanding that representatives from Telecom have argued to both U.S. and New Zealand government officials that the transmission frequencies used by the SES are too high to affect our measurements. Unfortunately, if we had been approached, as the treaty appears to require, we could have explained that our sensitive radio measurements are likely to be affected by the SES transmissions.

Over the years, scientists involved in sensitive radio measurements have been forced increasingly to move to the most remote regions of the earth to continue their measurements away from man-made interference. However, even in the remote Antarctic, these measurements are now threatened, despite the strict measures written into the Antarctic Treaty to protect the Antarctic environment.

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Superconducting Transition Temperature of Doped C_{60}: Retraction

We would like to retract our claim in our report of 8 November 1991 (*1*) that K/Tl or Rb/Tl codoping increases the superconducting transition temperature (T_c) of C_{60} relative to that for the well-known K_3C_{60} and Rb_3C_{60} superconducting phases. This claim was based on two different types of measurements made in two laboratories [low-field microwave absorption (LFS) by B.L.R. at Arizona State University and SQUID magnetic susceptibility by H.J.B. at Morris Research Inc.]. We now believe that no equilibrium phase having a T_c higher than that of the alkali metal–doped C_{60} was detected.

Both the SQUID and the LFS measurements initially made provided T_c's that were substantially higher for numerous C_{60} samples nominally doped with K/Tl or Rb/Tl alloys than for samples similarly doped in the absence of thallium. However, the SQUID results became suspect in December 1991, when all the authors realized that these measurements (both field-cooled and zero-field cooled) were being made during sample heating using a fast-scan program of the Quantum Design magnetometer, where temperature equilibration could not be ensured. Use of this rapid scan rate showed no significant effect on the observed T_c (compared with slow-scan data) for a reference sample ($Ba_{0.6}K_{0.4}BiO_3$, with T_c = 31.5 K), for samples of K_3C_{60} and Rb_3C_{60} and for numerous C_{60} samples annealed with the alkali metal/thallium alloy under conditions believed to result only in K or Rb doping. However, slow-scan dc SQUID and ac susceptibility measurements made on all nominally K- or Rb/Tl-codoped samples prepared from December 1991 to the present time have provided a T_c essentially identical to that of K_3C_{60} or Rb_3C_{60}, respectively, independent of the value of T_c obtained on fast scans. Zero-field cooled dc SQUID measurements by J. L. Costa-Kramer and K. V. Rao (Royal Institute of Technology, Stockholm) have confirmed this observation of a scan rate–dependent enhancement of apparent T_c for a Rb/Tl-doped sample and the absence of such an enhancement for C_{60} similarily doped only with Rb.

In the absence of T_c's above that of the alkali metal–doped C_{60} in the slow-scan SQUID data, we looked for possible errors in the LFS measurements. This investigation showed that a temperature drop existed between temperature sensor and sample in the cryostat used by B.L.R., and this temperature drop was higher for the K/Tl- and Rb/Tl-doped samples than for the corresponding K- and Rb-doped samples, thereby providing higher apparent T_c's for the former samples.

Among possible explanations for the anomalous scan-rate dependence of the apparent T_c for nominally K/Tl- or Rb/Tl-doped C_{60}, the most interesting would be that a Rb/Tl-codoped phase having a T_c above 30 K exists but that this phase is thermodynamically stable only below a first-order orientational phase transition temperature that is less than 30 K. If such were the case, observation of a T_c above 30 K only for fast heating rates might be understandable. Such an interpretation in terms of a hysteretic phase transition is consistent with observations on recently prepared $Rb/Tl/C_{60}$ samples of a higher apparent T_c for the initial fast-scan, zero-field cooled SQUID measurements than for subsequent identical measurements, as well as the observed elimination of the difference between fast-scan and slow-scan determinations of T_c after thermal annealing of the samples at temperatures of about 450°C. However, the above explanation would require the fortuitous near-coincidence of the T_c for the equilibrium high temperature phase