enhanced convergence, boundary layer destabilization, increased aerosols, or alteration of existing storms. D. Rosenfeld suggested that urban particulates act to delay conversion of cloud water into precipitation. Precipitation processes are delayed to greater heights in the clouds, respectively delaying the downdraft and allowing the clouds to invigorate further. In dry and unstable conditions, this causes reduced precipitation due to very low precipitation efficiency, and in tropical and moist subtropical conditions, enhanced storm vigor (increased updrafts, rainfall, lightning).

An important result of Rosenfeld's presentation is that it provides evidence of convergence between the UHI-dynamics and aerosol-microphysics arguments.

Human-related activities associated with transportation, energy production, and industrial processes are likely the sources of "urban" aerosols. A compelling body of evidence using ground and satellite data showed that aerosol optical thickness peaks during the middle of the week in New York City. This cycle was hypothesized to be related to increased transportation activity at the beginning of the business week. Emerging observational and modeling capabilities will help to clarify this finding and enable new discoveries. For example, it was demonstrated that satellite-derived columnar aerosol loading has shown good correlation (R=0.8–0.9) with Environmental Protection Agency (EPA) PM2.5 (particulate matter with particle size less than 2.5 mm) at the surface in urban areas like Houston, New York, and Chicago.

Even the carbon cycle is sensitive to the urban environment. Urban land transformation in the United States has reduced the amount of carbon fixed through photosynthesis by 1.6% of pre-urban values, according to M. Imhoff. This reduction nearly offsets the 1.8% gain made by the conversion of land to agricultural use. This is a striking fact given that urbanization covers less than 3% of the land in the U.S., while land under agricultural production approaches 29%. Using satellite data and a terrestrial carbon model, the impact of urbanization on net primary productivity (NPP) and its consequences for carbon balance and food production have been quantified. Urbanization is taking place on the most fertile lands and has a disproportionately large overall negative impact on regional- and even continental-scale NPP. In terms of biologically available energy, the loss of NPP due to urbanization alone is equivalent to the caloric requirement of about 6% of the U.S. population annually.

Urbanization will increase globally to reflect population migration to cities. The complexities of the Earth system are well known, but the relative influences and feedbacks of human-induced and natural forcings are not. The renewed focus on the urban environment is therefore timely and critical. Indeed, recent and upcoming international meetings in Lodz, Poland and Vancouver, British Columbia underscore the global interest in understanding the linkages between the urban environment and the climate system.

Acknowledgments

The authors would like to acknowledge Ramesh Kakar and Ming-Ying Wei (NASA HQ) for their support.

—J. Marshall Shepherd, NASA Goddard Space Flight Center, Greenbelt, Md.; and Menglin Jin, University of Maryland, College Park

Interdisciplinary Discussion of Volcanic Processes Beneath the Long Valley Caldera–Mono Craters Area

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Volcanism in the Long Valley Caldera–Mono Craters (LVCMC) volcanic field in eastern California over the past 4 Ma is dominated by the 0.76 Ma caldera-forming eruption of 600 km^3 of rhyolite to form the Bishop Tuff. Over the last 150 k.y., volcanism has concentrated along the Mono-Inyo chain, which extends 45 km north from Mammoth Mountain to Mono Lake (Figure 1, below). Recent eruptions along this chain have occurred from multiple vents 650 ± 50 yr B.P. and from a vent in the middle of Mono Lake ~300 yr B.P. An earthquake swarm in May 1980, including four M6 earthquakes accompanied by uplift of the resurgent dome in the center of the caldera, called attention to the restless nature of Long Valley caldera. Subsequent activity has included recurring swarms of earthquakes ($M \leq 5.8$), episodic uplift of the resurgent dome, diffuse outgassing of magmatic CO_2, and mid-crustal (10- to 25-km deep), long period (LP) volcanic earthquakes.

A 4-day workshop on volcanism of the LVCMC volcanic field was held recently on the southwest rim of the caldera. The workshop included over 65 participants from academia, government agencies, and the private sector, with participants from Italy, Japan, New Zealand, and Great Britain. A field trip led by Marcus Bursik, Wes Hildreth, and Gail Mahood visited deposits of the ~600 yr B.P. Inyo Domes eruptions, the Horseshoe Lake tree-kill area of high CO_2 flux, and outcrops of Bishop Tuff along Owens Gorge.

The goals of the workshop were to develop an interdisciplinary assessment of our current understanding of the LVMC volcanic system, and to identify outstanding questions that might be resolved with new observations or experiments, as a framework for guiding future proposals to both the U.S. National Science Foundation and the U.S. Geological Survey Volcano Hazards Program.

Wide-ranging discussions emphasized that, although we have learned a great deal about this complex magmatic system over the past 25 years, major questions have yet to be resolved. The most recent eruptions were localized along the Mono-Inyo chain, yet recent ground deformation has focused on the resurgent dome, and seismicity is concentrated beneath the south moat of the caldera, Mammoth Mountain, and the Sierra Nevada block south of the caldera (Figure 1).

Where is the next eruption most likely to occur? Could magma driving uplift beneath the resurgent dome erupt from vents along the Mono-Inyo chain? These questions highlight uncertainty in the size, distribution, and connectivity between magma bodies in the upper crust, as well as the deep roots of the magmatic system in the lower crust and upper mantle. Although magma intrusion seems a likely cause of uplift, available evidence does not preclude a role for magmatic brines or hydrothermal fluids. More broadly, the relationship between magmatism and basin-and-range extension remains unresolved.

Although viewpoints varied on many issues, the discussions revealed consensus on a number of points. While there is evidence for recent magmatic intrusion beneath the LVMC system, data do not support the existence of large (caldera-scale) magma bodies in the upper crust, as presumably existed prior to eruption of the Bishop Tuff. Seismic observations require fast, low attenuation wave-paths through the central caldera. Tomographic studies using local earthquake sources and magnetotelluric surveys show no evidence of a large magma body in the upper 10 km beneath the caldera. Furthermore, no volcanic activity has occurred in the eastern two-thirds of the caldera in the last 300,000 years (Figure 1). Eruption of basalts in the western third of the caldera in the last 150 k.y. limits the extent of any silicic melt pockets, which would prevent denser basaltic magmas from reaching the surface. However, the western structural boundary of the caldera, defined by the ring fracture system, is 2–4 km inboard of the topographic rim (Figure 1), such that most post-300 ka vents fall outside the structural caldera. Other evidence needing to be reconciled with any model of the LVMC system includes the lack of volcanic gas emission in the central caldera, and the decidedly cool temperatures (100°C at depths of 2–3 km) in the Long Valley Exploratory Well (LVEW) located near the center of uplift.

Considerable evidence supports recent emplacement of melt beneath both the resurgent dome and Mammoth Mountain. Evidence for intrusion in the central caldera includes uplift of as much as 80 cm during the past 2 decades. The uplift was accompanied by gravity changes that are interpreted to require intrusion of silicate melt. The deformation data constrain the shape (vertically elongate), the depth (6–10 km), and the volume change (~0.2 km^3 since the late 1970s), but not the total volume of the inflation source. Teleseismic tomography shows low P-wave velocities at mid-crustal depths (10–30 km) that are consistent with 10–20% partial melt. The fact that south-moat seismicity increases following the onset of accelerating uplift implies a causal link between the inflation source and south moat earthquakes.

Intermediate lavas erupted within the west moat show evidence of mixing with magma of Bishop Tuff affinity, indicating that some residual melts or partly crystallized residues remain. Although magnetotelluric data show no evidence for a low resistivity zone in the upper crust, the data have not been examined with current techniques and have limited depth resolution due, in part, to highly conductive rocks within the caldera fill.

Evidence for intrusion of small amounts of magma beneath Mammoth Mountain is stronger. The 1989 seismic swarm outlines a tabular zone, interpreted to be a dike in the upper 7 km of crust. Deep (10–20 km) long-period (LP) earthquakes, thought to represent fluid flow, began during the swarm, followed within a few months by the onset of CO_2 emission around Mammoth Mountain. Fumarolic ^{3}He/^{4}He ratios as high as 6, indicative of mantle sources, increased and have remained high since 1989. These data are best explained by emplacement of a small basaltic dike in late 1989. The ongoing CO_2 flux of ~300 tons/day, however, is too large to be explained by a single dike, suggesting longer-term gas accumulation or continued outgassing from a deeper magmatic source.

Earthquake focal mechanisms with clear volumetric (non-double-couple) components and the systematic migration of seismicity from 6 to 7 km up to depths of 4 km or less suggest fluid involvement in the earthquake swarms beneath Mammoth Mountain and the south moat. Strain transients and water level changes in monitoring wells are consistent with upward migration of fluids, possibly hydrous brines derived from magma. A conspicuous lack of a thermal anomaly and absence of volcanic gases dissolved in the hydrothermal system of the south moat suggests that deep magmatic fluids may be isolated from near-surface fluid reservoirs beneath the south moat.

An important goal of the workshop was to identify areas of future research with expected high payoff in terms of addressing outstanding problems. These recommendations include:

• Improve understanding of the link between regional tectonism and magmatism within the LVMC volcanic system and, in particular, the link between seismic activity in the Sierra Nevada and that within the caldera.

• Improve resolution of the structure and physical state of the upper 5–20 km of the crust using seismic, electromagnetic, and potential field studies, including the northern Mono-Inyo chain.

• Apply recently developed inversion techniques (for example, double difference tomography and receiver function inversion) to existing seismic data sets.

• Acquire new high-resolution seismic data using active and passive sources for better resolution of the structure and physical properties of the lower crust and upper mantle beneath the caldera and the deep roots of the magmatic system.

• Develop laboratory data on the influence of temperature, percentage of partial melt, and water content on seismic velocities in silicic rocks.

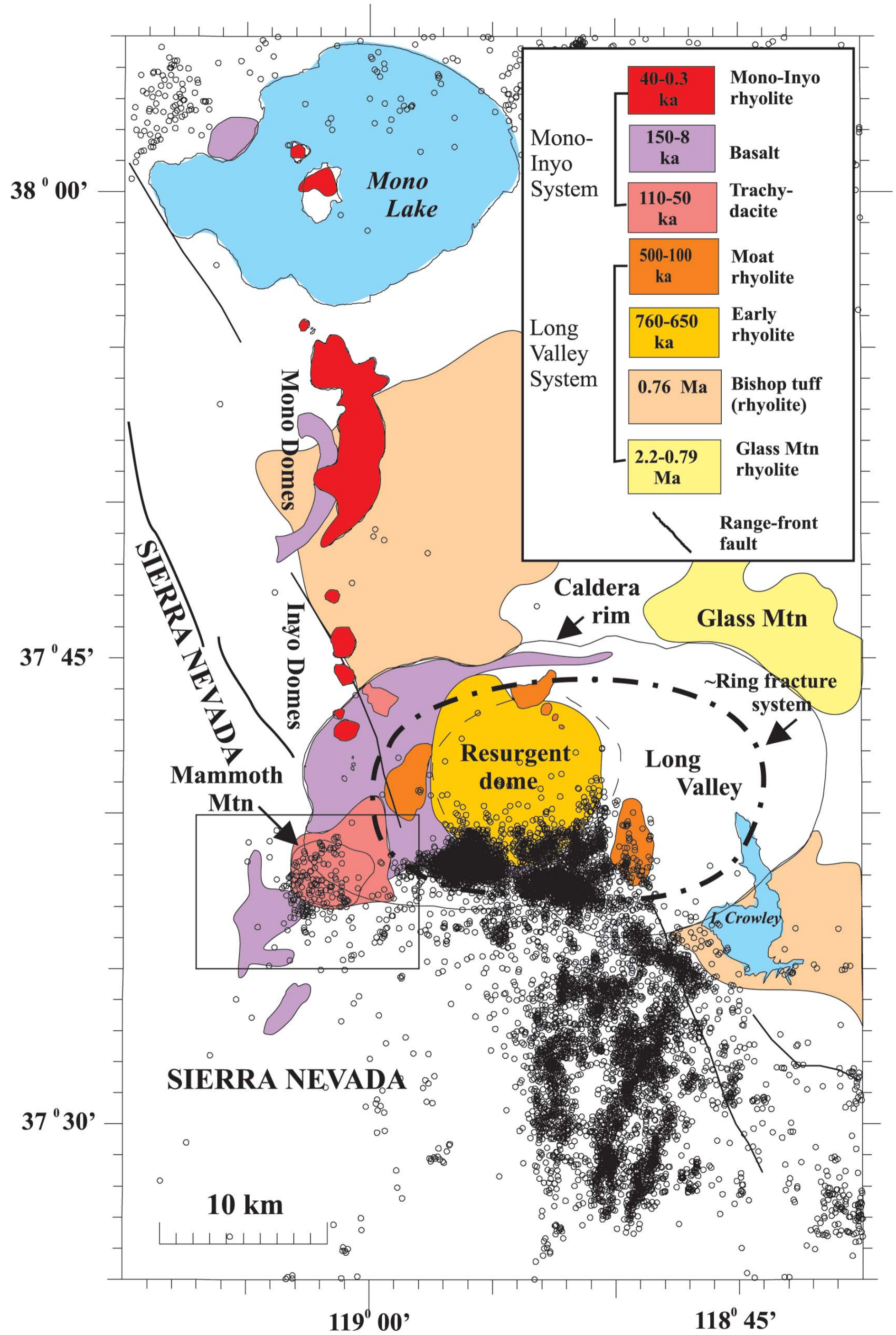

Fig. 1. The pattern of Holocene volcanism in the Long Valley–Mono Craters volcanic field is shown with epicenters for M ≥ 2 earthquakes (small circles) for 1978 through 1999. Geology is generalized from Bailey *[1989].*

• Analyze existing magnetotelluric data using current analysis methods, and undertake a modern MT survey, including data both within and outside the caldera.

• Complete simultaneous leveling, Global Positioning System, and micro-gravity surveys so that existing data in different reference frames can be unified, resulting in tighter constraints on the density of inferred intrusions.

• Analyze continuous deformation data from expanded arrays planned under the Plate Boundary Observatory (PBO) initiative to better constrain sources of deformation, including the seismogenic domain in the Sierra Nevada south of the caldera.

• Install additional three-component broadband seismometers for reliable full moment tensor inversions of earthquake source mechanisms.

• Obtain additional thermal, fluid, and geochemical data from existing and future wells to support realistic models including rock-fluid thermal interactions linking magmatic heat sources to seismicity and hydrothermal flow in the crust beneath the caldera.

The productive exchanges among specialists in different fields highlighted the importance of interdisciplinary research, field observations, modeling, and laboratory studies. Overall, the many positive comments by the participants suggest that the workshop was successful in meeting its objectives, and the participants seemed committed to working together to better understand this complex volcanic system.

The workshop was dedicated to the memory of Roy Bailey, who mapped and extensively studied the volcanic field, and who passed away in July 2003.

Understanding a Large Silicic Volcanic System: An Interdisciplinary Workshop on Volcanic Processes in Long Valley Caldera–Mono Craters was held 8–12 October 2003, in Long Valley, California.

Acknowledgments

The National Science Foundation and U.S. Geological Survey jointly supported the workshop with logistical support provided by UNAVCO. We are particularly grateful to Rose Price for her seemingly effortless skill in dealing with the many challenges that inevitably arise in organizing a workshop of this size.

Reference

Bailey, R. A. (1989), Geologic map of Long Valley Caldera, Mono Inyo Craters volcanic chain, and vicinity, eastern California, *U.S. Geol. Surv. Misc. Investig. Ser. I-1933*, 1:62,500, pp. 11.

—DAVID HILL, U.S. Geological Survey, Menlo Park, Calif.; and PAUL SEGALL, Stanford University, Calif.

GEOPHYSICISTS

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In Memoriam

James R. Holton, 65, 3 March 2004, AGU Fellow, Atmospheric Sciences, 1966.

Buford K. Meade, 2004, AGU Fellow, Geodesy, 1946.

Mikhail I. Pudovkin, 70, 18 February 2004, Magnetospheric Physics, 1978.

Honors

The following AGU members received 2004 awards and medals from the European Geosciences Union, presented at the EGS-AGU-EUG Meeting in Nice, France.

Michel Blanc received the Jean Dominique Cassini Medal and Honorary Membership "for his outstanding work on the magnetospheres of the Earth and of giant planets of the solar system, and his role in the preparation of the Cassini/Huygens mission to Saturn and Titan." Blanc has been an AGU member (Magnetospheric Physics) since 1978.

Alberto Borges received the Outstanding Young Scientist Award "for his significant contribution to the understanding of air-sea CO_2 fluxes in coastal ecosystems." Borges joined AGU (Biogeosciences) this year.

Paola Vannucchi received the Outstanding Young Scientist Award "for her important studies of subsidence in subduction zones using innovative techniques which have contributed significantly to our understanding of these zones." Vannucchi has been an AGU member (Tectonophysics) since 1998.

Michael A. Hapgood received the Union Service Award "reserved for individuals in recognition of their outstanding service and/or exceptional efforts in the promotion, growth and running of the Union." Hapgood has been an AGU member (Magnetospheric Physics) since 1982.

Subir Banerjee received the Louis Néel Medal "for his outstanding contributions in rock magnetism, paleomagnetism and environmental magnetism, together with exceptional services to the geoscientific community." Banerjee is an AGU Fellow (Geomagnetism and Paleomagnetism) who joined in 1967.

Lev Vinnik received the Beno Gutenberg Medal "for his pioneering studies in observational seismology and the introduction of widely used analysis techniques." Vinnik is an AGU Fellow (Seismology) who joined in 1989.

John Wahr received the Vening Meinesz Medal "for his outstanding and far-ranging contributions in the field of global geodesy." Wahr is an AGU Fellow (Geodesy) who joined in 1978.

Forrest Mozer received the Hannes Alfvén Medal "for his pioneering work on electric field measurements in space plasma." Mozer is an AGU Fellow (Magnetospheric Physics) who joined in 1960.

Vladimir N. Zharkov received the Runcorn-Florensky Medal "for his many important contributions to planetary science, especially related to the interior structure and chemical composition of Mars." Zharkov is an AGU member (Planetology) who joined in 1992.

Michael Ghil received the Lewis Fry Richardson Medal "for his fundamental research on testing and improving climate models based on nonlinear analysis of geophysical time series." Ghil is an AGU Fellow and Life Member (Atmospheric Sciences) who joined in 1983.

BOOK REVIEW

The Mass Balance of the Cryosphere: Observations and Modelling of Contemporary and Future Changes

JONATHAN BAMBER AND TONY PAYNE (EDITORS)
Cambridge University Press, Cambridge, U.K.; ISBN 0-521-80895-2 (hardback); xvii + 644 pp.; 2004; $130.

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"Vanishing sea ice!" "Disintegrating ice shelves!" "Rising sea level!" Such proclamations illustrate the widening gap between the kind of glaciology that makes newspaper headlines and the kind of glaciology which is reinforced in standard scientific texts. It is as if there were two kinds of ice: a benign form such as that studied by Victorian gentlefolk and a new rogue form, of concern to the Intergovernmental Panel on Climate Change (IPCC).

In truth, the difference is one of perspective: ice as a feature of the local land- or seascape versus ice as an active component of the Earth system. From the global perspective, the two most important attributes of Earth system ice, a.k.a. the cryosphere, are its high albedo (leading to a positive climate feedback) and the large mass of stored freshwater—roughly 70 m of sea-level equivalent. These aspects are addressed in several chapters of the IPCC's *Third Assessment Report, Climate Change 2001*. J. Bamber and T. Payne's ambitious book provides the backstory in the form of a coherent treatise.

Mass balance studies have been tarred with the brush of banality. The introduction to Paterson's First Edition of *The Physics of Glaciers*, for example, states: "In the author's opinion, a mere handful of mathematical physicists, who may seldom set foot on a glacier, have contributed far more to the understanding of the subject than have a hundred measurers of ablation stakes or recorders of advances and retreats of glacier termini." Yet, mass balance considerations are foremost when one ponders the future of the cryosphere. By reformulating the motivational basis of glaciology, Bamber and Payne, assisted by 21 other contributing authors who will be identified when their contributions are described, align the science with the societal issues. Although one tends to prefer books written by a small number of authors, such a preference would rule out the possibility of a book of this scope. Furthermore, the list of contributors is stellar.

The foreword by Sir John Houghton, retired co-chair of IPPC Working Group I and lead editor of its assessment reports, establishes at the outset that this is a book with High Purpose. Short introductory and concluding chapters by the editors enclose the five-part structure that forms the main body of the book. Part I is concerned with observational techniques and methods, and contains chapters on in situ measurement techniques for land ice (J. O. Hagen and N. Reeh), sea ice (P. Wadhams),