political scientist, also spent innumerable hours presenting their perspectives on building interdisciplinary careers and interacting with colleagues from different disciplines and beyond the scientific community. During both formal and informal meetings, they shared their day-to-day experiences as professional scientists and their perspectives on the future of climate change research. Jerry and Ron also led sessions on job-hunting and mentoring of undergraduate and graduate students. By being official mentors at the DISCCRS symposium, they have both agreed to be available to the participants to address questions and concerns that may arise throughout the early stages of their careers.

In addition to providing an overview of climate-related research, the symposium enabled the participants to establish a diverse peer network that has already been put to use. This network should encourage interdisciplinary thinking, result in new pathways for addressing climate change research, and enrich the participants throughout their professional lives. Most of the participants have encountered obstacles and challenges to building interdisciplinary scientific careers. The main problem is continued disciplinary segregation in both the education and publication processes. While these challenges can be daunting, the symposium showed how interdisciplinary science can work and what can be accomplished by transcending the traditional disciplinary boundaries.

Acknowledgments and Final Notes

We extend special thanks to C. Susan Weiler for her excellent organization of the DISCCRS program and symposium; to Ashley Simons for reviewing this manuscript; and to Ron Kiene and David Kieber, who have made their collaborative proposal available electronically for use as a model to new scientists (http://aslo.org/phd/modelproposal.pdf). Pending success of a new proposal, a second DISCCRS symposium will be held in 2005. In the interim, the DISCCRS Ph.D. Dissertation Registry and news list sign-up will continue at http://also.org/phd.html.

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MEETINGS

Great Plains Workshop Held to Prepare for USArray Deployment

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Relative to most parts of North America, the Great Plains region, which is bordered by the Rocky Mountain Front on the west and the Mississippi River on the east, has been understudied in terms of the structure, formation, and evolution of the underlying crust, mantle, and core. The anticipated arrival of the USArray portable seismic stations, which will cover the entire United States regardless of surface geology and tectonic activities, and the deployment of the accompanying flexible array stations and the permanent seismic stations in this area, will fill this gap and address numerous problems related to the structure and dynamics of the Earth. Detailed information about USArray can be found at http://www.earthscope.org/usarray/.

To maximize the effectiveness of the upcoming USArray, formulate cooperative studies, and identify geologic targets for detailed studies using the flexible array stations of USArray, a pre-EarthScope Great Plains workshop was recently hosted by Kansas State University's Department of Geology. The workshop brought together about 40 geoscientists with interests ranging from surface processes to mantle dynamics, from about 25 institutions. Participants discussed scientific objectives related to USArray's Great Plains coverage, with an emphasis on future collaborations to maximize our understanding of the geology of the Great Plains region, from the Earth's surface to the core-mantle boundary. This will lead to a better understanding of the geologic development of cratonic regions, and provide valuable data for integrated studies of continental lithosphere and deep Earth structure over a wide range of scales.

Presentations and posters of related geological and geophysical research provided useful background information for the discussions. The workshop concentrated on the topical problems highlighted below.

Formation of the Great Plains

The Great Plains region, currently part of the "stable" North American Platform, had an active tectonic history in the Precambrian period. Most of the Precambrian metamorphic and igneous rocks are covered by Phanerozoic sedimentary strata of marine and non-marine origin. The basement of the Great Plains consists of a series of island arcs accreted to the craton by Proterozoic collisions in the area between the current Rocky Mountains and the Nemaha Uplift to the Canadian Shield. All of these accretionary features persisted as zones of weakness in the crystalline basement, and were the trends of rejuvenation during periods of regional stress. This is an ideal locale for studying accretionary features such as the composition, thickness, and fabrics of the crust and mantle at different stages of the Earth's history, and for gaining a better understanding of plate tectonic processes using data from USArray.

In the Great Plains region, surface and subsurface structure displays a series of anticlinal arches that are attributed to horizontal contraction. The gentle folds may be associated with the final phases of the late Paleozoic Appalachian orogeny, and the Mesozoic and Cenozoic Laramide orogeny. These structures indicate that the lithosphere is capable of transmitting stresses into the continental interior. Detailed mapping and analysis of those intra-continental structures, using data from USArray, will provide critical information on intra-cratonic deformation and the strength of the lithosphere.

Crustal and Mantle Structure Beneath the Mid-continental Rift

Geophysical study of major continental rifts has been largely focused on modern rifts. It is now clear that beneath most modern rifts, there is a thinned crust and up-warped asthenosphere which replaced a significant part of the continental lithosphere. It is unclear, however, whether the modified lithosphere will become normal or remain chemically distinct after the rifting process ceases, and whether the "lost" crust will be reclaimed. The 1.1-billion-year-old Mid-continental Rift (MCR) is an ideal location to answer those questions.

MCR is a 2000-km-long and 100-km-wide feature. It extends from Kansas, or possibly farther south to New Mexico and Texas, through Iowa, Minnesota, and Wisconsin, before turning southeastward into Michigan. During the 20–40 million years of rifting, which is a relatively short period compared to the rifting duration of other ancient and modern rifts, it was a zone of considerable seismicity and volcanism, which erupted a layer of basaltic lava up to about 20 km thick along the rift valley. These rocks yield large gravity and magnetic anomalies. Results from previous seismic experiments suggest normal mantle velocities and thickened crust beneath the MCR. In addition, it seems that the original mantle fabrics associated with the rifting process have been eliminated or significantly weakened. Those results, if confirmed by USArray, will enable us to better understand the post-rifting evolution of the hot and possibly depleted mantle beneath continental rifts.

Transition from the Rocky Mountains to Great Plains

The nature of the transition from the western U.S. orogenic zones and the stable Great Plains in the mantle is an important factor to consider in any model linking High Plains uplift to larger scale plate processes and mantle convection. Previous teleseismic studies indicate thick crust, high attenuation, and low mantle P- and S-wave velocities beneath the Rocky Mountains and thin crust, low attenuation, and high P- and S-wave velocities beneath the Great Plains. No significant variations for mantle transition zone thickness from the Rocky Mountains to the Great Plains were obtained, indicating that the differences between the two regions are restricted to the crust and upper mantle.

Shear-wave splitting studies show that the transition from the "Rocky Mountain type" anisotropy to the "Great Plains type" anisotropy takes place in central Kansas. Stations in the Rocky Mountains show weak anisotropy and/or spatially varying fast polarization directions. Stations in the Great Plains show mostly northeasterly fast directions, which are parallel to the absolute plate motion direction. Due to limited seismic stations in the transition region, more data from USArray will certainly provide additional constraints to determine the crust and mantle structure and composition from orogenic belts to the cratonic interior of the continent.

Formation of the Black Hills

The Black Hills uplift is part of a Laramide arch that extends from western Montana to the Chadron uplift in northwestern Nebraska, and transverses both the Wyoming-Trans-Hudson and Trans-Hudson/Central Plains province boundaries. Local Laramide-style deformation features may be affected by older basement faults and zones of weakness. The timing and composition of Laramide-age magmatic activity in the northern Black Hills may reflect the geometry of the Archean-Proterozoic crustal suture and the depths of the two lithospheric roots. High-quality seismic data obtainable through USArray and additional surface geology work in the Black Hills area will greatly enhance our knowledge of the three-dimensional geometry of the uplift, the nature of the Wyoming-Trans-Hudson suture zone, the nature of Laramide-style faulting in the upper crust, and possible magma source regions and conduits.

Cause of South Dakota Gravity Low

Bouguer gravity anomalies show that a pronounced gravity low occupies much of south-central South Dakota. It is also an area with higher-than-normal heat flow values. Various models have been proposed for the cause of the gravity low, such as groundwater erosion related to the Ogallala aquifer, low-density igneous rock in the basement, and low-density, hot rocks related to a mantle plume. Data from high-resolution components of USArray and high-accuracy dating of surface rocks and cores will provide information about the origin of the gravity low.

In addition to these topics, other Great Plains considerations discussed during the workshop include deformation of the North American lithospheric keel, depth and geometry of the subducted Farallon plate, structure and deformation of the New Madrid zone, earthquake hazard in the Great Plains, and the driving mechanism for the Rio Grande rift. Participants in the workshop agreed that pre-USArray collaborative studies are critical for the success of the upcoming project. In addition to the important problems mentioned above, more questions will be raised regarding the formation, evolution, and structure of the North American platform as a result of those studies. An executive committee was formed to coordinate pre-USArray study activities in the Great Plains region. Detailed information about the workshop can be found at http://earth.geol.ksu.edu/usarray.

The workshop titled "USArray and the Great Plains: A Pre-EarthScope Workshop" was held 23–25 April 2003, in Manhattan, Kansas.

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FORUM

Comment on "When Earth's Freezer Door Is Left Ajar"

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As a glaciologist, I wish I could believe *Hezi Gildor*'s [2003] provocative Forum article, that warming favors ice growth up to rather high temperatures, and that the future may hold more beautiful glaciers for my colleagues and me to study. Unfortunately, far too much evidence indicates that warming will reduce the extent of ice on Earth, and has done so under a wide range of past conditions, including the ice age cycling of the Pleistocene [e.g., *Rahmstorf*, 2002].

For most of the Earth's glaciers today, accumulation of snowfall in colder places is removed primarily by melting in warmer places. Anything that affects either accumulation or melting, including temperature, precipitation, cloud cover, relative humidity, wind speed, debris cover, seasonality of these, and more, can affect glacier balance, as can a host of ice-flow processes [e.g., *Paterson*, 1994; *Oerlemans*, 2001].

And yet, recent warming has reduced glaciers, when averaged over many sites and over the time scales for dynamical fluctuations, and future warming is expected to continue and even accelerate this trend. For example, from *Oerlemans* [1994], "The retreat of glaciers during the last 100 years appears to be coherent over the globe... [and] can be explained by a linear warming trend of 0.66 kelvin per century" (p. 243). *Gregory and Oerlemans* [1998] subsequently predicted continued glacier melt in response to future global warming, and found that including regional and seasonal effects increased the estimated melt by 20%.

On longer time scales, the reduced mid-Holocene glaciers cited by *Gildor* [2003] and known from elsewhere occurred during orbitally induced mid-Holocene warmth [e.g., *Miller*, 2001], with glacier growth following and presumably resulting from cooling [also, see *Oerlemans*, 2001 (chapter 9)]. Inverse correlations of temperature and glacier extent during the Holocene are well-documented and have long been used in paleoclimatology [e.g., *Denton and Karlen*, 1973; p. 196]. For ice age events, the ice core records from central Greenland show quite clearly that the local warming from the most recent global ice age began about 24 kabp, and was well underway before sea level rise began between about 21 and 19 kabp [e.g., *Alley et al.*, 2002]; taking the Greenland record as representative of broader regions, warming preceded ice melt, and causality seems highly likely.

Dominant temperature control of glaciers ending on land arises because their mass balance is more sensitive to typical temperature changes than to typical precipitation changes. The highest rates of precipitation on Earth reach only about 10 m/a, but observation of mountain glacier termini, or of snowplow piles in shopping-mall parking lots, shows that much higher ablation rates are achieved easily. Warmer air does bring higher saturation vapor pressure, and thus higher precipitation if all other factors are unchanged, but by only approximately 10% per degree. However, my informal survey of a range of recent papers on glacier mass balance [including *Greene et al.*, 1999; *Kayastha et al.*, 1999; and *Braithwaite and Zhang*, 2000, which themselves survey many glaciers] indicates that offsetting the effects of a 1 K warming for modern glaciers requires approximately 40% increase in snowfall. This agrees well with *Oerlemans* [2001, p. 128], who in summarizing a study by the European Ice Sheet Modelling Initiative (EISMINT) of the response of a range of mountain glaciers and ice caps to coming climate change, noted that "The melting of ice due to climatic warming is not easily compensated for by an increase in