Recommendations from the Workshop on Cyberinfrastructure (CI) for the Integrated Solid Earth Sciences (ISES)

ISES-CI Steering Committee

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Framing Statement

The Integrated Solid Earth Science (ISES) effort arose from the Solid Earth Sciences workshop held in conjunction with the 2002 Geological Society of American meeting. The goal of ISES is to create a common voice for areas of geology that focus on the solid earth, including geochemistry, geochronology, paleontology, petrology, sedimentology, stratigraphy, structural geology and tectonics (essentially the disciplines in the CD, GE, CH and TE Programs, and to an extent PH and IF Programs, within the Earth Sciences Division of the National Science Foundation). This alliance formed in the Fall of 2002 as a result of a grass-roots effort, and the Solid Earth Science community is actively working to coordinate and articulate common community visions for science, research, and participation in the Cyberinfrastructure revolution. The last aspect, which is termed ISES-CI, was the focus of a NSF-funded workshop held at the University of Kansas on March 28 and 29, 2003. This report and the development of an ISES-CI organization follow on the community consensus built at this workshop. This ISES-CI effort is ongoing, is separate from, but coordinated with, the ISES role in helping create a science vision for the contributing domains.

> *ISES-CI is the vehicle for participation of ISES domains in the CI revolution. Several working groups formed to take advantage of community consensus reached at the ISES-CI workshop. These working groups will foster new areas of effort, help nurture nascent areas, and work to solidify collaborations among mature endeavors.*

The ISES-CI workshop concluded that there is a pressing need to develop databases and analysis and synthesis tools, and to ensure interoperability of ISES datasets and tools in keeping with other disciplinary CI efforts at NSF. At present, there are many ongoing collaborative efforts that need to be fostered, there are natural collaborations that need to be cultured, and there are others that have yet to be organized but are identified. The

process of evaluating needs, developing consensus, and building community support was started during the ISES-CI workshop by selecting key scientists to serve as steering committee leaders for each of these areas. The resulting working groups will help facilitate the ISES communities through ISES-CI in the overall Geoinformatics efforts in the Geoscience community.

> *Watchwords for ISES-CI: Integrative, inclusive, easy, distributed but seamless. The ISES-CI workshop concluded that a system must be developed for easy data upload and transfer with embedded tools for initial analysis that creates seamless integration and visualization of distributed datasets, and that empowers the larger community to join in the CI revolution.*

ISES-CI Working Areas

The ISES-CI workshop identified ten priority areas (see below) that are critical to the future progress of the ISES and their integration into the broader spectrum of Geosciences and other related areas of science. Provisional steering committee leaders in most of the following areas have been identified and contacted. The leaders will establish working groups to start, nurture, or conclude community efforts on CI needs, participation, and protocols. The working groups will make presentations at the ISES meeting held at the Geological Society of America meeting in Fall, 2003. The specific areas and brief summaries are given below. They are described fully in the formal committee report.

1) **Geochemistry of igneous and sedimentary rocks.** This effort is fairly mature in that there are groups working already on databases for both oceanic and continental igneous rocks. Igneous suites for the oceans are the focus of PetDB (funded by NSF-OCE); continental rocks are being covered by NAVDAT (funded by NSF-EAR) and GEOROC (funded by the Max Plank Institute fur Chemie, Mainz, Germany). Compilations for sedimentary rocks are being included in the budding CHRONOS organization. The combination of ISES-CI help and the participation from NAVDAT, GEOROC and PetDB as well as CHRONOS means that this effort is close to fruition. Kerstin Lehnert (PetDB), Richard Carlson (NAVDAT), and Bruce Wardlaw (CHRONOS) are coordinating efforts to ensure full coverage of geochemistry. In addition, tool development will be explored by making ties to the metamorphic and rock properties efforts described below, and by the involvement of modeling groups such as the MELTS (NSF small ITR) project.

2) **Geochemistry of metamorphic rocks and metamorphic petrology.** This effort is starting but has yet to fully organize. This group can establish synergistic relationships with the geochemical efforts mentioned above and structural geology efforts mentioned below. At present, the community must decide upon data standards, reporting information, and just what information is critical. The individual identified for leadership of the working group that will advance this effort is Frank Spear (RPI).

3) **Geochronology and thermochronology of the Earth.** Working groups have already been established for this area through the CHRONOS organization. Although the main aim of these efforts is programmatic to the time scale effort of CHRONOS, the overall database structure and exploration protocols are quite generally applicable. ISES-CI will coordinate with CHRONOS in database and tool development. In addition, we will attempt to involve cosmogenic dating where appropriate. The group leaders will be Mark Schmitz (DTM and Boise State) and Dan Stockli (Kansas).

4) **Structural Geology.** This effort is starting but has yet to fully organize. The current plan is to organize a workshop for the structural geology community to establish a schema to accommodate structural observations at all scales (from thin section to mountain range. Ties will be established to the metamorphic effort described above. In addition, this group requires the critical incorporation of geologic maps and their exploration (see below). The group leaders will be Jeff Lee (Central Washington), CJ Northrup (Boise State) and John Oldow (Idaho).

5) **Physical properties of rocks and minerals.** This effort is starting. The main need here is to establish accessible databases and exploration tools for the fundamental properties of rocks, including attenuation, anisotropy, seismic velocity, mineralogy, composition, etc. Some of required data will be populated in other databases. Access to these data in an integrated form is critical to many aspects of ISES research and especially to the new EarthScope effort. Exploration of the steps needed to make such information available will be lead by Basil Tikoff (Wisconsin), Alan Byrnes (Kansas Geological Survey), and Tracy Rushmer (Vermont).

6) **Maps.** This effort is starting but is as yet poorly organized. Because the spatial content of most ISES data is critical, the creation of maps is vital. Maps of interest run all the way from the basic field data and relations presented on geologic maps, to the critical insights possible from creating and using derived maps such as paleogeography, paleotectonics, and palinspastic reconstructions. Coordination with the USGS and GSA is critical to this because of ongoing efforts of these groups to publish maps and charts. We will identify soon individuals to work with USGS and GSA and the ISES community.

7) **Stratigraphy.** This effort is starting but has yet to fully organize. The current plan is to organize an effort in physical stratigraphy that will consist of a steering committee and workshop. The organizers for this have been identified: Becky Dorsey (Oregon), Peter Issacson (Idaho), Jim Trexler (UNR), and Walt Snyder (NSF and Boise State University). Coordination with CHRONOS and GeoVision (small NSF ITR project) will be done as well as ties to industry.

8) **Field data acquisition techniques.** There is much active research on using new technologies for field data acquisition. The groups working on this have made great progress, but because the field is so new, there has been no attempt to organize the community of researchers. The ISES-IC committee recommends that these efforts

coordinate under an organization we call INTERFACE *(**INTER**disciplinary alliance for digital **F**ield data **AC**quisition and **E**xploration)*. This is viewed as an alliance that will involve not just geoscientists, but also biologists, ecologists, geographers, and any other domains that rely on field data acquisition by individuals or small groups. We have identified Carlos Aiken (UT Dallas), Kelin Whipple (MIT), and Doug Walker (KU) as group leaders in this effort.

9) **Tools for data integration and exploration, and creating the *ISES Colaboratory*.** All of the efforts described above would benefit greatly from the ability to visualize and analyze diverse datasets and models in a 3-D environment. We have identified several group leaders to create or foster such a system: Jonathan Lees (UNC), Morin (Minnesota), Randy Keller (UTEP), James Handschy (ConocoPhillips), and Eric Frost (Cal State San Diego). Integrative efforts are necessary, and tools envisioned by the ISES-CI committee would allow for the seamless blending of ISES data with those coordinated by CHRONOS, GEON and any geophysical-CI groups (e.g., CI products from IRIS and UNAVCO). These tools also will help enable the type of integrative research at the heart of the EarthScope Program. In addition, the ISES-CI group considers a Colaboratory effort (e.g. a distributed laboratory) that allows for interdisciplinary interactions (including integrating real-time field data acquisition into office efforts) to be an appropriately ambitious goal.

10) **Sample Archiving.** Many aspects of ISEC research relates to samples of Earth materials that are collected at considerable expense either from remote areas of the planet or by expensive coring. In addition, research specimens in ISES fields also include unique and irreplaceable materials such as xenoliths from the lower crust and mantle. Many of these particularly unique samples serve as components of diverse research efforts extending over many years to decades. Other communities within the earth and planetary sciences recognize the importance of archiving these research specimens, for example meteorites, ocean floor rocks, limnological collections, and Antarctic samples. Curation of particularly important solid earth samples would provide an important service to the ISES community and is well justified on the basis of the cost of replacing these samples. This conclusion is supported by a recent report from the National Academy of Sciences. Many models of sample curation were discussed at the workshop ranging from a centralized facility to a simple electronic card catalog that keeps track of samples being kept in individual researcher's personal collections. Steve Goldstein (LDEO) and Paul Kimberly (Smithsonian) will lead a working group to develop the needs and cost-benefit aspects of sample archiving for the ISES community.

ISES-CI along with GEON, CHRONOS and the PBO and USArray data management programs, will provide the mechanism to facilitate truly interdisciplinary/integrated science, as pursued currently by the EarthScope Project, that will lead to more developed understanding of the Earth as a complete and interacting system involving its solid earth, oceans and atmospheric shells.

To make progress on the areas describe above, the ICES-CI committee and the working group leaders have agreed upon the following time line. The effort started at the workshop in March 2003. Many working groups will contribute preliminary reports within one month that will be included in the workshop report. The working groups will continue their activities and prepare detailed recommendations by the time of the GSA and AGU meetings in the Fall of 2003. After developing community consensus, the working groups will spawn proposals to implement the ISES-CI system at the start of 2004. Within 1 to 2 years, these proposals will start to produce results that will foster a cultural shift in the ISES community toward the adoption and integration of the ISES-CI system. At first, the effort will involve small groups. This will expand to the community level to build consensus. After this, it is anticipated that smaller functional groups will organize to prepare the ISES-CI proposals. The working system in the end will then be used across the entire community.

The timeline: