

## 2012 Geothermal Technologies Peer Review Summary: State Geothermal Data

### 1. State Geological Survey Contributions to the National Geothermal Data System

- Association of American State Geologists (AASG), managed by the Arizona Geological Survey
- Principal Investigator: M. Lee Allison, Ph.D.
- Email: [lee.allison@azgs.az.gov](mailto:lee.allison@azgs.az.gov), Direct Phone: (520) 209-4121, Fax: (520) 770-3505
- Core Project Team:
  - Co-Principal Investigator: Stephen M. Richard, Ph.D.
  - Budget Analyst: Tony Corcoran
  - Project Coordinator: Kim Patten
- Subcontractors and Participating Organizations:
  - Subcontractors (44)
    - i. Geological Surveys (State Agency or University Based):
      1. AL, AK, AR, AZ, CO, FL, IA, ID, IL, IN, KS, KY, LA, MA, ME, MI, MN, MO, MS, MT, NC, NH, NJ, NM, NV, NY, OH, OK, OR, PA, RI, SC, TN, TX, UT, VA, VT, WA, WI, WV, WY
    - ii. Universities:
      1. HI, ND (for NE & ND), SD (Sinte Gleska University)
  - In-Kind Participants: CA through AZ; CT through MA; DE, GA, and MD through the VA, NE and ND through UND, SD
  - Network Partners and Collaborators:
    - i. USGS Community on Data Integration, Western Regional Partnership, International GeoSample Number eV, State of Arizona, Energistics, Microsoft Research, and the GeoNet Community of Practice (DataONE, EarthChem, Energistics, ESIP Federation, AUScope/Australian National Data System, IRIS Data Management Center, NEON, NOAA, Natural Resources Canada, OneGeology, iPlant Collaborative, USGS)

### 2. Project Objectives and Purpose

The project objective is to expand and enhance the National Geothermal Data System (NGDS) populating a national, sustainable, distributed, interoperable network of state geological survey-based data servers and services. The geological surveys will develop, collect, serve, and maintain geothermal-relevant data through network nodes provided as an integral component of NGDS. As a result the geothermal industry, the public, and policy makers will have access to consistent and reliable data, reducing the staff time devoted to finding, retrieving, integrating, and verifying information. Easier, more efficient access to information will reduce the cost and risk of exploration drilling.

This project relates to the GTP mission, goals, and objectives since it facilitates and streamlines discovery, evaluation, and access to geoscience and geospatial information used to locate, evaluate, and develop geothermal resources. The project expedites acquisition of information to promote the discovery and development of large-scale geothermal energy production facilities as well as other practical applications such as direct use and residential/commercial ground source heat pumps. The data system provides expanded reference and resource data for research and development activities and includes data from across all fifty states, incorporating not only high-temperature potential but also moderate and low-temperature information.

The goal is to advance successful resource exploration through increased data availability for known geothermal resources while contributing new data from previously unexplored locations.

### 3. Technical Barriers and Targets

The project faces a variety of significant technical challenges related to developing, implementing, and populating interchange formats for more than 30 data content models that will usefully account for the wide variety of in-

formation being compiled by the states. The metadata content scheme must account for all resources of interest, and its use documented sufficiently to allow the data providers to accurately populate metadata records. We are utilizing off-the-shelf, preferably free, open-source software as much as possible. This requires evaluating available products and familiarizing the team with configuration and operation of several systems. This learning and evaluation process has been time-consuming. Design of interchange formats for the actual geoscientific data requires consideration of potential use cases as well as the actual data that are available to balance current capabilities, design complexity, and desired future capabilities. Locating and hiring staff with the necessary mix of training and experience with geoscientific data, information management, and web architecture has also been a major challenge. Significant effort has been devoted to hiring and training staff at AZGS and training partners at the regional server hubs and 44 data-providing institutions.

Target metrics for this year include:

- June 1, 2012: Receive and review data from second-year subcontracts in preparation for review of Statements of Work for next cycle
- September 30, 2012: Enhanced user access and user interface developed
- September 30, 2012: Draft data maintenance and sustainability strategy
- December 31, 2012: Majority of new field data collected
- April 1, 2013: Majority of all committed data online and operational

#### 4. Technical Approach

Our technical approach is to conduct data acquisition throughout the project in roughly annual cycles. In each cycle, subcontractors develop a Statement of Work (SOW) identifying specific deliverable data for that cycle, prioritizing the types of data most in demand or most critical to identifying and characterizing its geothermal resources. The project Science Advisory Board (SAB) reviews and approves each SOW before data acquisition begins and evaluates results before recommending approval to AZGS for the next cycle.

Data item types are identified by the AZGS team based on submitted SOWs; interchange content models for these items (features or observations) are developed, reviewed by the community and DOE GSDPWG (NGDS Development and Population Technical Working Group), documented and tested to bring data online. These content models are then posted to [www.stategeothermaldata.org](http://www.stategeothermaldata.org) and [www.geothermaldata.org](http://www.geothermaldata.org) (Boise State University maintained) web sites, and used for subsequent contributions of data.

AZGS staff reviews sample data products and works with the subcontractors to assure that datasets conform to the adopted content models and interchange formats. Final delivered products are reviewed by AZGS to determine if the SOW has been met to complete the cycle; progress is publicly tracked on <http://www.stategeothermaldata.org/progress>. NGDS resources are published and become part of the system when metadata records describing them are published by a node in the NGDS catalog system, and the described resource is available online and accessible using information in the metadata record.

#### 5. Technical Accomplishments

- Established internal Quality Control and Assurance measures for incoming data.
- Launched public website ([www.stategeothermaldata.org](http://www.stategeothermaldata.org)) which includes a project management section for sub-recipients.
- Regional server and four IT hubs established and operational; held a workshop for hub managers at AZGS to discuss technical and backup requirements for the system.
- Participated in authoring the National Geothermal Data System (NGDS) Architecture, Design, Testing, and Maintenance continuation plan, which established system wide advisory and coordination groups.
- Supplemental funding projects for new field data awarded and undergoing NEPA review.
- Deployed the USGIN metadata catalog using ESRI Geoportal Server Open Source Project (v.10) consuming metadata using ISO 19139 for metadata management, discovery, and Catalog Services for the Web (CSW).

- Harvested existing ISO metadata and OGC GetCapabilities documents from Web Map Services and harvesting OGC WFS GetCapabilities and FGDC xml-encoded metadata into Geoportal. Harvest processes use xslt transformations to convert XML to USGIN ISO-profile conformant metadata.
- Geospatial Data Services (Web Map Services, Web Feature Services, and Web Coverage Services) have been deployed on all hub servers; 219 services are available as of 3/27/2012.
- Developer's site <http://lab.usgin.org> maintained to provide information related to service profiles and implementation approaches for the USGIN that are being used for state geological survey NGDS services.
- URI dereferencing application implemented, using Django to register and redirect http URI's to resolve URIs in the NGDS web services to produce responses according to the data provider's guidance. This uses a rule based approach to rewrite http URI's to URLs that retrieve useful representations of information resources.
- Repository launched to upload documents for use by the community.
- Develop and deploy 'Metadata Wizard' tool to create, manage, and export metadata to the catalog service. It is designed for information resources that are already accessible with existing URLs.
- Develop a web-based metadata creation and maintenance to extend functionality available in repository and metadata wizard tools; records can be imported, edited, validated, inspected and approved before exporting to a web-accessible directory and harvested by the catalog. This process keeps the catalog in sync with the online tools and repositories.
- Develop a software application that validates metadata in the tabular template format using a collection of user defined rules. The validation tool will work for content as well.
- Develop a software application to bulk load metadata records from the compilation spreadsheet by reading metadata records from spreadsheet rows serializing as XML that can be imported to the catalog.
- 20 data delivery content models are now available and in-use
- A total of 473 datasets have been submitted. Of those, 208 are online, 117 are approved and pending service, and 148 have been submitted and are either in review or returned for additional content. Note that not all WMS/WFS services are listed; these are only the services that are on the regional server hubs. States that are serving their own data go through the XML and data validation procedure and are self-hosted.

## 6. Challenges to Date

Subcontracting delays rather than technical issues account for the most critical challenge to the project. It took almost one year from project start date to finalize the subcontracts with 44 subrecipients and agreement from 6 in-kind participants. Additional administrative delays include hiring freezes in many states and environmental (National Environmental Policy Act, NEPA) clearance for the new data collection projects. We have resolved these challenges by adjusting the deliverables timeline for the subrecipients and redirected existing staff. Subrecipients have also redirected their staffing efforts to existing employees or contractors.

The challenges have impacted technical deliverables only in the sense that the deliverables have been delayed respective to the aforementioned challenges. We have requested a no-cost extension through 12/31/2013.

## 7. Conclusion and Plans for the Future

We have released a prototype functional data system with multiple data nodes and nationwide data online and available to the public. The data includes more than 20 data types and represents nearly 2,000,000 records (online or in queue). We have streamlined our data tracking and submission process through online project management and innovative database management. We have continued to improve the technical components and are implementing strategies to facilitate catalog registration.

Key activities for Year-3 include comprehensive data production. That is, adding additional geothermal relevant data sets to the system. We also will review and approve of each state's Year-3 work plan based on work progress in Years 1 and 2. Reviews are conducted by the project's Science Advisory Board this year scheduled for June 14-15, 2012 in Austin, TX. The 4 regional server hubs will continue to accept data and will contribute to the sustainability and backup plans due by the fall of 2012. The production of training programs – including online webinars and tutorials – will continue. Most of the new data acquisition will take place over the next year including drilling a minimum of 21 gradient and research holes in 6 states (ID, NV, OR, UT, WA, WI).

We also plan to improve and enhance the user experience and access to the data and the system. Preliminary discussions with third-party client application developers have commenced. In-house development of application plug-ins has also started.

## 8. Publications and Presentations – Publications listed from May 1, 2011 to May 1, 2012 (by AZGS)

### Publications

Allison, M. Lee, Richard, M., Clark, Ryan C., Patten, Kim, Love, Diane S., Coleman, Celia, Chen, Genhan, Matti, Jordan, Day, Janel, Pape, Esty, and Musil, Leah, 2011, "Online, interactive assessment of geothermal energy potential in the U.S." Proceedings, Thirty-Seventh Workshop on Geothermal Reservoir Engineering. Stanford University, Stanford California, January 30-February 1, 2012. 7pages.

### Talks

Allison, M. Lee, "Everything Digital, Online, and Interoperable," Americas Petroleum Survey Group, 25th Annual Conference, Houston, TX, May 6, 2011

Allison, M. Lee, June 15, 2011, "Geothermal Data Project Annual Meeting Review," Association of American State Geologists Annual Meeting, Breakout Session, Dubuque, Iowa

Allison, M. Lee, June 13, 2011, "Web Accessibility," Association of American State Geologists Annual Meeting, Breakout Session, Dubuque, Iowa

Allison, M. Lee, June 30, 2011, "US GIN and Related Activities," OneGeology Operational Management Group Annual Meeting, Edinburgh UK

Allison, M. Lee, and Stephen M. Richard, ESIP Federation Summer Meeting, July 12, 2011, "Geoscience Information Network (GIN) Town Hall," Santa Fe, NM, [http://wiki.esipfed.org/index.php/July\\_12,\\_2011](http://wiki.esipfed.org/index.php/July_12,_2011)

Richard, Stephen, M. Lee Allison, and Ryan Clark, "Distributed web services for geospatial geologic information," ESRI User Conference, San Diego, CA, July 13, 2011

Richard, Stephen M, and Vivian Hutchinson, "Sustaining Community Efforts in the Geosciences: The Future of the US Geoscience Information Network," USGS Community on Data Integration workshop, Denver CO, August 17-18, 2011

Patten, Kimberly, and Lee Allison, "State Geological Survey Contributions to the National Geothermal Data System," State of Arizona, Governor's Office of Energy Policy, Geothermal Heat Pumps in Arizona Policy Workshop, September 22, 2011

Anderson, Arlene F., Cuyler, David, Snyder, Walter S., Allison, M. Lee, Blackwell, David D., and Williams, Colin F., "National Geothermal Data System," Geological Society of America, Minneapolis, MN, October 9, 2011

Allison, M. Lee and Gallagher, Kevin T., "U.S. Geoscience Information Network: A Critical Path for Data Integration in the U.S. Earth Sciences," Geological Society of America, Minneapolis, MN, October 11, 2011

Love, Diane S., Coleman, Celia, Pape, Esty, Clark, Ryan C., Richard, Stephen M., and Allison, M. Lee, 2011, State Geothermal Survey Contributions to the National Geothermal Data System: Geological Society of America, Minneapolis, MN, October 9, 2011

Patten, Kimberly, Allison, M. Lee, and Richard, Stephen M., "U.S. Geoscience Information Network: Distributed Deployment Across 50 States," Geological Society of America, Minneapolis, MN, October 11, 2011

Jackson, Ian, Broome, John, and Allison, M. Lee, "Delivering Geoscience Knowledge in Federal Systems," Geological Society of America Abstracts, Minneapolis, MN, October 12, 2011

Allison, M. Lee, Renewable Energy, Geologic Hazards, and Risk," Arizona Land Subsidence Group and Association of Environmental & Engineering Geologists (AEG) Conference on "Opportunities for Alternative Energy Development in Arizona and the Southwest – Geologic/Hydrologic Considerations," 2011 Shlemon Speciality Conference, Tempe, AZ, October 27, 2011

Wunsch, David, and M. Lee Allison, "Web-based Information Services Available from State Geological Surveys to Assist Your Well Contracting Business," National Ground Water Association Annual Meeting and Expo, November 30, 2011

Andersen, Arlene F., David Cuyler, Walter S. Snyder, M.L. Allison, David D. Blackwell, Colin F. Williams, "National Geothermal Data System," American Geophysical Union Annual Conference, San Francisco, CA, December 7, 2011

Allison, M.L., Stephen M. Richard, Ryan Clark, Celia Coleman, Diane Love, Esty Pape, Leah Musil, "Online, interactive assessment of geothermal energy potential in the U.S." American Geophysical Union Annual Conference, San Francisco, CA, December 7, 2011

Gallagher, Kevin T., M.L. Allison, "A Critical Path for Data Integration in the U.S. Earth Sciences," Poster Session, American Geophysical Union Annual Conference, San Francisco, CA, December 9, 2011

Jackson, Ian, Henry John Broome, and M.L. Allison, "Delivering Geoscience Knowledge in Federal Systems: What Can the Old and New Worlds Learn from Each Other?" Poster Session, American Geophysical Union Annual Conference, San Francisco, CA, December 9, 2011

Allison, M. Lee, Richard, M., Clark, Ryan C., Patten, Kim, Love, Diane S., Coleman, Celia, Chen, Genhan, Matti, Jordan, Day, Janel, Pape, Esty, and Musil, Leah, 2011, "Online, interactive assessment of geothermal energy potential in the U.S." Thirty-Seventh Workshop on Geothermal Reservoir Engineering. Stanford University, Stanford, CA, January 30-February 1, 2012.

Allison, M. Lee, "AASG Update," AIPG National Board Mid-Year Meeting, Tucson, AZ, February 10, 2012.

Allison, M. Lee, "AZGS Update," AIPG Arizona Section Annual Business Meeting, Tucson, AZ, February 11, 2012.

Anderson, Arlene, Cuyler, David, Snyder, Walter, Allison, M. Lee, Blackwell, David, and Williams, Colin, "National Geothermal Data System," American Association of Petroleum Geologists Annual Conference, Long Beach, CA, April 24, 2012 [Poster]

Allison, M. Lee, Richard, Stephen M., Clark, Ryan C., Patten, Kim, Love, Diane S., Coleman, Celia, Chen, Genhan, Matti, Jordan, Day, Janel, Pape, Esty, and Musil, Leah, "Online, Interactive Assessment of Geothermal Energy Potential in the U.S.," American Association of Petroleum Geologists Annual Conference, Long Beach, CA, April 24, 2012 [Poster]

Meeting, American Association of Petroleum Geologists Annual Conference, Long Beach, CA, April 25, 2012

Allison, M. Lee, Atkinson, R., Arctur, David K., Cox, Simon, Jackson, Ian, Nativi, Stefano, Wyborn, Lesley A., "International Convergence on Geoscience Cyberinfrastructure." European Geosciences Union, Vienna, Austria, April 25, 2012

Allison, M. Lee, Gallagher, Kevin T., Richard, Stephen M., Hutchison, Vivian, B., "Strategic Roadmap for the U.S. Geoscience Information Network." European Geosciences Union, Vienna, Austria, April 25, 2012. [Poster]

**Briefings**

Richard, Stephen M. "USGIN and NGDS status report". IUGS CGI Interoperability Workgroup Meeting, Edinburgh, Scotland, July 4, 2011

Allison, M. Lee, Western Regional Partnership 4th Principals Meeting, Salt Lake City, UT: update on NGDS, GIN and progress on working agreement for data integration with WRP, September 16, 2011

**Online Presentations**

AZGS Webinar: "Reviewing Data for Online Delivery," May 17, 2011

Richard, Stephen M. "USGIN and WRP" (linking WRP's catalog to the GIN network), AZGS Webinar, September 12, 2011

Allison, M. Lee, January 29, 2012, "How GIS works as a User App for Digital Data Networks," GIS in Mining and Exploration Online Summit 2012, Session 8, Webinar series hosted by Mining IQ, January 23-February 3, 2012.

Webinar. Lehnert, Kerstin. "Introduction to IGSN and SESAR," March 8, 2012 [31 attendees]

**Exhibits**

Geothermal Energy Association National Geothermal Summit, Reno, NV August 16-17, 2011

Geothermal Resources Council 35th Annual Meeting and GEA Trade Show, San Diego, CA, October 23-26, 2011 [AZGS State Geothermal Data exhibit booth]

Geological Society of America Annual Meeting, Minneapolis, MN, October 9-12, 2011 [AZGS State Geothermal Data exhibit booth]

American Geophysical Union Fall Meeting, San Francisco, CA, December 5-12, 2011 [AZGS State Geothermal Data exhibit booth]