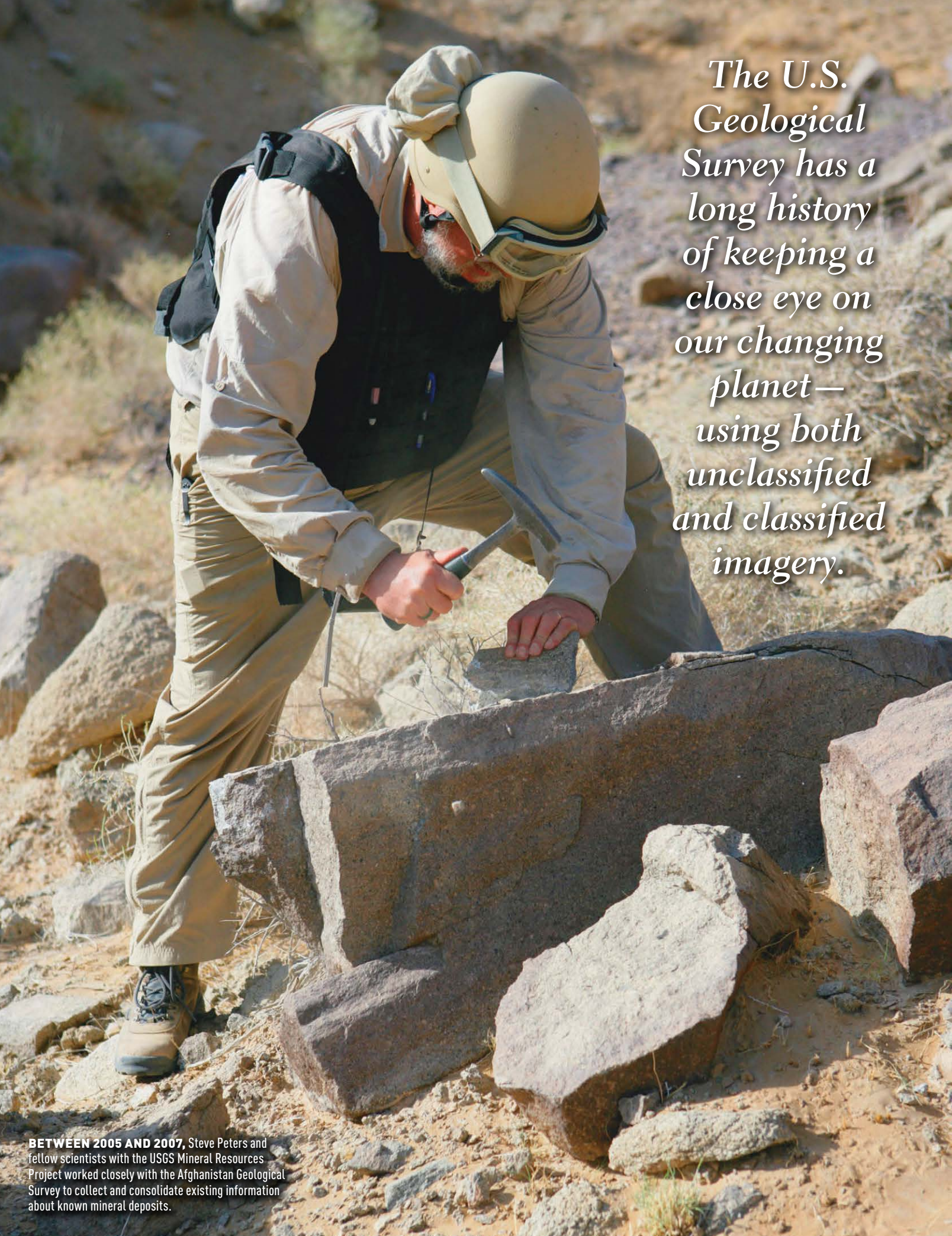

The U.S. Geological Survey has a long history of keeping a close eye on our changing planet—using both unclassified and classified imagery.

BETWEEN 2005 AND 2007, Steve Peters and fellow scientists with the USGS Mineral Resources Project worked closely with the Afghanistan Geological Survey to collect and consolidate existing information about known mineral deposits.

BY MELANIE D.G. KAPLAN

eyes on the earth

In August 2007, three geologists from the U.S. Geological Survey (USGS) landed at Kandahar Airfield in Southern Afghanistan to support a mission with the Afghanistan Ministry of Mines and Petroleum and the DoD Task Force for Business and Stability and Operations to rebuild the country's geological survey.

As NASA pilots flew WB-57 research jets overhead outfitted with hyperspectral imaging spectrometers, the trio of geologists helped set paths for 28 flights and reviewed data for accuracy. If the planes had been lawn mowers, they would have traversed the entire country, stripe by stripe, imaging what would later show, unequivocally, world-class mineral deposits with the potential to bring economic stability to Afghanistan.

PHOTO COURTESY OF USGS

"Logistically it was hard," said Jack Medlin, USGS regional specialist for the Asia Pacific Region, who has managed this project for the last decade. "It's not often scientists go into a war zone. But when you do, there are certain risks—you just want to make sure the risks to the people are minimized."

That includes ensuring everyone knows the scientists are engaged in, well, science. Medlin said their finished work—like all that comes out of USGS—becomes publicly available. This, in turn helps fulfill the agency's mission, which is to serve the nation by providing reliable scientific information that can be used in many different ways, ultimately to better understand the Earth and enhance and protect quality of life.

In this case, the project yielded images covering 170,000 square miles, marking the first time most of a country has been mapped via hyperspectral technology. The data set, which will be used by scientists, environmentalists, miners, policy-makers, and investors, consists of more than 800 million pixels, resulting in numerous reports and dozens of maps, the last of which was released in September.

MONITORING THE EARTH, 24/7

If USGS had a hall of fame covering its 135-year history, the Afghanistan mission may very well be a new inductee. Other all-stars could include the training of astronauts who landed on the moon in 1969; the volcano team's accurate forecast of the 1991 eruption of Mt. Pinatubo in the Philippines, which saved hundreds of thousands of lives; and the assessment of damage from the Gulf of Mexico's Deepwater Horizon oil spill in 2010.

But rather than a hall of fame, the Reston, Va.-based headquarters' hallways are filled with an extraordinary collection of maps.

Creator of The National Map—a collection of 57,000 topographic maps charting every U.S. river, valley, and railroad, and used by recreationalists, engineers and planners, scientists, and educators—USGS employs approximately 8,500 people, about half of whom are scientists. Since the agency's early years, it has used science to understand natural heritage. Even before USGS was created, President Thomas Jefferson commissioned Lewis and Clark's exploration of the American West, to map the land and collect information about soils and plants. Since then, the drive to discover and understand the Earth hasn't waned. At its core, USGS translates complex Earth science into findings and warnings that help form better policy and disaster preparation.

USGS Senior Advisor for Science Applications Jim Devine is a seismologist by training who covered his childhood bedroom walls with maps of the Pacific theater and followed the early movements of World War II. He said the agency has been moving in the same fundamental direction since its foundation in 1879—learning the geology, topography, and hydrology of the Earth.

"We are the world's earthquake and volcano monitors," he said, pointing to a large photo of Mount St. Helens behind his desk. "We send our people out at the worst possible times, and we also provide baseline information for less catastrophic situations, such as water quality and wildlife."

Devine barely touches on the overwhelming number of areas in which USGS conducts science. But among the most significant changes at USGS in recent years is the agency's increased use of technical assets to understand natural resources and respond to disasters. Access to daunting amounts of geospatial information, persistent GEOINT capabilities such as 24/7 monitoring of streams and earthquakes, and the declassification of certain images obtained by spy satellites and other sensors have changed the game at USGS.

"We have a long history as a member of the GEOINT Community," USGS Acting Director Dr. Suzette Kimball said in April during her keynote address at the GEOINT 2013* Symposium. "We have done great work together between the federal and civil communities, and the intelligence and defense communities."

She noted in her keynote that contributing to the Intelligence Community (IC) continues to be a USGS priority, especially with tools and technologies that are mutually beneficial.

DECLASSIFYING DATA

Bert Beaulieu, a National Geospatial-Intelligence Agency (NGA) senior manager on a one-year assignment to the USGS director's office, said ease of access to improving technology has caused the use of remote sensing to soar. Among his tasks is to make the availability of these images better known to scientists within and outside of USGS.

"Higher resolution imagery can improve the fidelity of anything you're trying to describe," Beaulieu said. "And by using some of the classified capabilities, you can enhance many details, down to vegetation and soil types."

He is also charged with expanding the use of classified sources among civil agencies, which goes back to the '60s, when the government realized it was prudent to use its best capabilities for dual purposes.

Beaulieu said a number of defense capabilities developed in support of warfighting over the last decade have proven beneficial on the civilian side—from the

USGS Fast Facts

- USGS was founded in 1879 and has studied the geology, topography, and hydrology of the Earth for 135 years.
- The USGS mission is to provide reliable scientific information that can be used in many different ways: to describe and understand the Earth; to minimize loss of life and property from natural disasters; to manage water, ecosystem, energy, and mineral resources; and to enhance and protect quality of life.
- The Survey is the nation's largest civilian mapping agency.
- USGS is aligned under the U.S. Department of the Interior.
- USGS has approximately 8,500 employees, about half of whom are scientists.
- USGS is headquartered in Reston, Va., and has more than 400 science centers throughout the country.
- The Survey has more than 2,000 partners from state, local and tribal governments, the academic community, other federal agencies, NGOs, and the private sector.
- The USGS maintains the National Earthquake Information Center.
- Notable USGS programs and initiatives include The National Map, the Hazard Data Distribution System, Landsat Earth observation missions in cooperation with NASA, the Global Fiducials Library, and the Civil Applications Committee.

Inside the CAC

USGS Senior Advisor for Science Applications Jim Devine loves to talk about his work. But he'll stop short if you ask one too many questions about the Civil Applications Committee, known as the CAC, which coordinates the use of data and imagery collected via U.S. National Technical Means (NTM).

The CAC developed out of the work of a World War II veteran and USGS scientist who began using classified satellite images for topographic mapping in the 1960s. The charter that created the committee in 1975 allowed civilian agencies to access classified images for non-military, non-classified purposes. USGS manages the CAC, acting as liaison between the intelligence and defense communities and civil agencies.

The CAC coordinates and filters requests from federal civil agencies, which are then approved by NGA. It then converts the images into a declassified product, disseminates the information, and protects intelligence sources and methods.

"We do this in close conjunction with the Intelligence Community," Devine said. "They know what we do—we're very, very careful to stay within those bounds, and we're not ever allowed to step over the lines. That would ruin our ability to access this information."

In addition to traditional mapping, CAC activities include remote sensing applications such as monitoring sea ice, glaciers, and volcanoes; detecting and tracking wildfires; coordinating emergency response to natural disasters; and monitoring ecosystems. In addition to USGS, the National Science Foundation, National Oceanic and Atmospheric Administration, Federal Emergency Management Agency, U.S. Department of Agriculture, and the Army Corps of Engineers are among the most prolific users of the imagery.

In partnership with the CAC, USGS also manages the Global Fiducials Library, an archive that maintains a long-term imagery record of environmentally significant sites around the world. The program began with the CIA a couple of decades ago in an attempt to answer questions about how the Earth was changing, such as what are the national security implications of a sea level rise?

The program monitored 500 locations worldwide over time, revealing the impact of rapidly changing coastlines and invasive species. In the last six years, the program has started to make images available to the public and has received approval to release more than 6,000 images covering about 125 sites.

hyperspectral sensor technology used by USGS for the minerals map in Afghanistan, to LiDAR 3-D surface modeling.

"The civil community has benefited from some of the sensor technology," he said, adding USGS is also a proponent of using UAVs as a safe and relatively inexpensive way to monitor volcanoes. "More cartographers die in airplane crashes than from snakebites or anything else," he said. "UAVs are much less disruptive or invasive in wilderness areas than scientists."

Devine said the biggest advantage for civilian access to declassified assets is that many capabilities would be too expensive to otherwise acquire.

"As long as we don't violate the agreement not to reveal sources and methods, it's a marvelous thing to have," he said, referring to the deal with the Intelligence Community requiring USGS to protect its sources when converting images into a declassified product. "It's a prime example of good government."

PREDICTING THE FUTURE BY EXAMINING THE PAST

Among the more undervalued assets at USGS are the historical data sets that have created an effectual time machine of the Earth's recent past. For example, USGS has monitored U.S. stream flow for 125 years.

"The result is we can tell you if something's part of a normal pattern, or if it's really unusual," said Mike Foose, chief of USGS's Africa and Middle East programs. "Making observations for long periods is hugely important to identify what's out of the ordinary, whether it's a food event in the Horn of Africa or flooding in Mozambique."

Some of the most widely used and celebrated USGS images come from the 42-year-old, Apollo-inspired Landsat program, developed in partnership with NASA. Landsat images document land changes such as glacial retreat, forest fires, and urban expansion. The two Landsat satellites that remain operational, Nos. 7 and 8, collect nearly 1,000 images daily, which are sent to USGS's Earth Resources Observation and Science (EROS) Center near Sioux Falls, S.D., for processing. The two million archived images are available to the public for free and provide a unique resource for those who work in agriculture, geology, forestry, regional planning, education, mapping, and global change research.

EROS is also home to the Hazard Data Distribution System, which facilitates the collection of images from Landsat and other sources such as DigitalGlobe and makes them available to disaster response teams. The center responds to around 75 disasters a year.

USGS is experiencing rising demand for its data by federal agencies and the emergency response and humanitarian communities. In the Horn of Africa, USGS uses Landsat images to monitor crop development as part of the Famine Warning System funded by the U.S. Agency for International Development (USAID). Foose said USGS has also used L-band radar to look below the desert sands in Darfur, Sudan, to map sub-surface water—which improved water drilling success in the region from 45 to more than 98 percent.

Whether it's a government agency, NGO, or academic institution, USGS customers and partners say they can't get enough data, images, and information. The need for more—and faster—data is particularly acute for users that make forecasts, such as the U.S. Department of Agriculture, or those who respond to disasters, such as the Federal Emergency Management Agency.

In coming years, USGS customers are likely to find more streamlined data, available more broadly, according to Kimball. Also in store: a renewed effort to train the next generation of cartographers and remote sensing experts, and further collaboration and idea-exchange with NGA.

THE TWO LANDSAT SATELLITES THAT REMAIN OPERATIONAL, NOS. 7 AND 8, COLLECT NEARLY

1,000

IMAGES DAILY.

INTERACTIVE HISTORY

The USGS Historical Topographic Map Explorer brings to life more than 178,000 maps dating from 1884 to 2006. Visit *trajectorymagazine.com* or download the *trajectory* tablet app for links to this interactive website and a host of others created by USGS.