The establishment of a geophysics field camp in northern Thailand

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As a participant in SEG's Geoscientists *Without* Borders program, we have developed a geophysics field camp in northern Thailand to train students and professionals from throughout Southeast Asia in field-based geophysical methods. Over the past two years, faculty, technicians, professionals, and students from 18 institutions and 11 countries have acquired, processed, and interpreted geophysical data at field sites in and around Chiang Mai, Thailand. Participation from undergraduate students, graduate students, and private and public sector geoscience professionals provides a broad base of experience, background, and insight. Our training has provided opportunities for cross-cultural collaboration and education, and a greater use of field-based geophysical methods for academic, private sector, and government agencies throughout Southeast Asia.

Overview

The Geoscientists *Without* Borders (GWB) program was created to help connect universities and industries with communities in need through projects using applied geophysics as a means to benefit people and the environment around the world. With GWB funding, our goal is to educate and connect local geoscientists with students throughout Southeast Asia (Figure 1). Our objective with field-based training is to instruct participants using modern geophysical instrumentation and software to address environmental and engineering problems by utilizing a range of geophysical tools. During 2010 and 2011, approximately 100 professionals and students participated in the Chiang Mai, Thailand trainings (Table 1). Our goal is to not only directly tackle specific near-surface geophysical projects, but to provide scenarios to train local professionals and students to address hazards or geosciences problems found within their own country's borders. By providing the tools and skills necessary to address groundwater, geotechnical, and archaeology problems, we hope to leave a lasting impact on geoscientists and geotechnical projects throughout Southeast Asia.

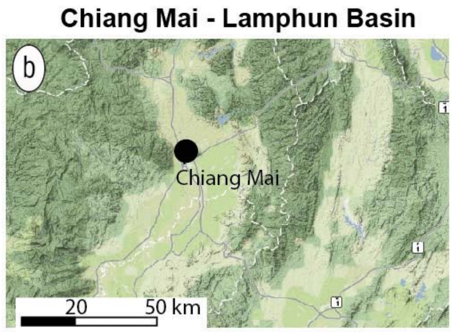

Figure 1. *(a) Map of Thailand and neighboring countries. Students and professionals from Thailand, Burma, Laos, Malaysia, Indonesia, and Vietnam participate in our training. (b) Northern Thailand terrain map. The Chiang Mai-Lamphun Basin, is one of many intermountain fault-bounded extensional basins of the region. All geophysical field sites are within 20 km of Chiang Mai.*

Institute	Institute
Boise State University (USA)	Kasetsart University (Thailand)
Chiang Mai University (Thailand)	Mahidol University (Thailand)
Chulalongkorn University (Thailand)	Phu Bia Mining Limited (Laos)
Colorado School of Mines (USA)	Prince of Songkla University (Thailand)
Department of Mineral Resources (Thailand)	Royal Irrigation Department (Thailand)
Department of Groundwater Resources (Thailand)	Siam Tone Co., Ltd. (Thailand)
Electricity Generating Authority (Thailand)	Universiti Teknologi Petronas (Malaysia)
Gadjah Mada University (Indonesia)	Vietnam National University (Vietnam)

Table 1. *Participant institutions from 2010 and 2011.*

Field sites were selected to train participants in the use of geophysical methods to address groundwater, archaeology, and geohazard concerns throughout the Chiang Mai Basin, Thailand (Figure 1). The field camp consists of one week of geophysical data acquisition using seismic, ground-penetrating radar, electromagnetic, resistivity, gravity, and magnetic methods (Figure 2). A second week includes data analysis, interpretation, presentation and a student-authored report. Data sets, reports, and presentations generated during our training are freely available (*http://cgiss.boisestate.edu/gwb*) and are being used for further instruction (e.g., data reprocessing, improved interpretations). This model was revised from other geophysical field schools (e.g., Colorado School of Mines, Boise State University and Imperial College, 2010) and existing collaborations between institutions.

Faculty, graduate students, and technicians from the United States, Canada, Australia, and Thailand provide instruction both in the classroom and field settings (Table 2). Introductory lectures by local experts and visiting faculty discuss field sites and overview geophysical methods applicable at each site. An instructor for each geophysical tool and field site guides the participants through training in acquisition, processing, and interpretation. All instruction is in English with at least one bilingual (Thai) participant in each group and a 3:1 student/instructor ratio. Participants from government and private agencies looking to broaden their geophysical base provide additional benefit of experience and leadership to student participants. Many institutions provide geophysical instrumentation and technicians to benefit the field camp and minimize the number of geophysical instruments brought from western countries.

Field sites

The area surrounding Chiang Mai, Thailand (Figure 1) is ideal for geophysical training due to pleasant seasonal weather, rich culture, the large physical property contrast within a sedimentary basin, and a wide range of geological-, hydrogeological-, archaeological-, and hazard-related problems. Selection of field sites is based on proximity to Chiang Mai to address a broad assortment of science objectives that are identified by geoscience faculty at Chiang Mai University. To provide experience with a range of geophysical tools and objectives, we image a shallow aquifer to characterize geology and hydrogeology at both water table and basin-scale depths. Additionally, we assess earthquake hazards for the Chiang Mai region by characterizing both the ground motion amplification and site response throughout the Chiang Mai-Lamphun Basin. Additionally, we identify and characterize faults that may be active. Lastly, we select archaeological sites of historic significance to identify and characterize buried structures that may provide important insights into past cultures.

Groundwater characterization at Mae Hia

Mae Hia, an abandoned landfill, is presently an agriculture research center for Chiang Mai University. The 517-acre site is approximately 5 km south of Chiang Mai, located within one of the highest groundwater exploitation areas of the region, and is highly vulnerable to groundwater pollution (e.g., Margane and Tatong, 1999). We acquired seismic reflection,

Figure 2. *(clockwise from top left): Geonics ProTEM 57 time-domain electromagnetic acquisition system with instructor Rob Harris at Mae Hia; high-resolution seismic survey to map a buried wall at Wat Pan Sao; Thai and Indonesian students acquire seismic data; resistivity acquisition at Wiang Kum Kam; ground-penetrating radar acquisition with temple monk observers at Wat Pan Sao; Hoai Trung Dang collects magnetic data at Wat Pan Sao.*

resistivity, electromagnetic, and gravity data in profile to map stratigraphy, geologic structures, and hydrogeologic boundaries in a basin dominated by tilted Tertiary strata overlying metamorphic basement rocks (e.g., Morley et al., 2001; Grissemann et al., 2004; Rhodes et al., 2005).

We acquired five resistivity profiles throughout the Mae Hia campus (Figure 3). Near-surface conductive zones identified on resistivity profiles represent fluvial deposits shed from adjacent foothills with a water-table transition zone identified in the upper few meters below land surface. Time-domain electromagnetic and gravity profiles identify the general

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Geonics Limited (Canada)	Rob Harris
Royal Irrigation Department (Thailand)	Noppadol Poomvises
The University of Western Australia	Jeffrey Shragge

Table 2. *Instructors from 2010 and 2011.*

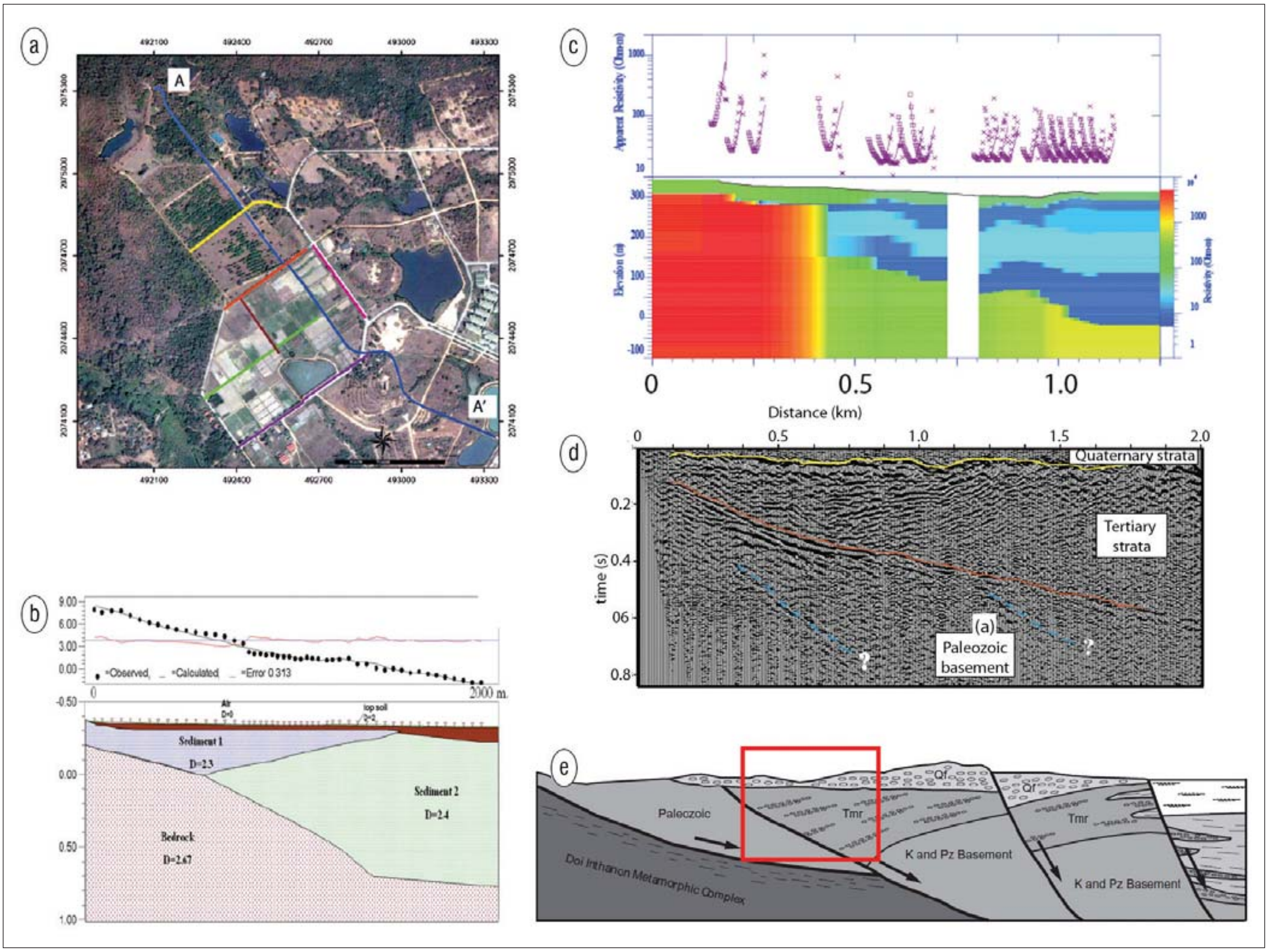

Figure 3. (a) Aerial photograph from Mae Hia with geophysical line locations. Gravity, EM-57, and seismic data from profile A-A'. (b) Gravity profile with observed and calculated measurements providing a first-order estimate of basin thickness. (c) EM-57 profile and measurements show increasing thickness of resistive basin sediments overlying a more conductive basement. (d) Seismic reflection profile shows a shallow water table and northwest-dipping Tertiary strata overlying a low-angle Paleozeoic basement. (e) Interpretive cross section across the Chiang Mai basin (from Rhodes et al., 2004) with interpreted low-angle faults separating Tertiary strata from older basement rocks. Red box represents area imaged with gravity, EM-57, and seismic reflection methods during our study.

basin configuration while a 48-channel seismic reflection profile characterizes the east-dipping bedrock surface, overlying west-dipping Tertiary strata, and low-angle faults (Figure 3). Our results show that high-quality geophysical results can be obtained with equipment available in Thailand and are being used to better constrain groundwater and structural models for the Chiang Mai Basin to address contaminant flow. Future studies using our geophysical methodologies are being planned for other portions of Chiang Mai and nearby basins to characterize groundwater, stratigraphy and geologic structures. Data integration between geophysical methods provides key insights to provide a geologic and hydrogeologic framework for the Mae Hia region.

Hazards studies

The Chiang Mai-Lamphun Basin is one of several intermountain graben and half-graben rift basins that comprise the northern Thailand Basin and Range Province (e.g., Morley et al., 2001; Rhodes et al., 2005; Figure 3). The basin has a maximum width of about 45 km, a length of over 130 km, and an area of about 3000 square km (Figure 1). As a component of the field training, we collect multichannel surface wave (MASW) data to determine shear-wave seismic velocities in the upper 30 m (VS30 measurements) at many sites throughout the basin and along an earthen dam (Poomvises et al., 2010). These values can provide estimates of site amplification from local or regional earthquakes (e.g., Park et al., 1999). Near-surface materials at these field sites contain a range of lithologies and velocity values that can provide a foundation for a probabilistic hazard map for the region (Figure 4).

In addition to MASW measurements, participants acquire seismic reflection, seismic refraction, electromagnetic, magnetic, and gravity data along profiles within the Chiang Mai Basin. Additionally, in 2010 we installed a broadband seismometer to characterize local ground motion from regional earthquakes. We interpret basin structure, characterize the transition between modern fluvial deposits and Tertiary

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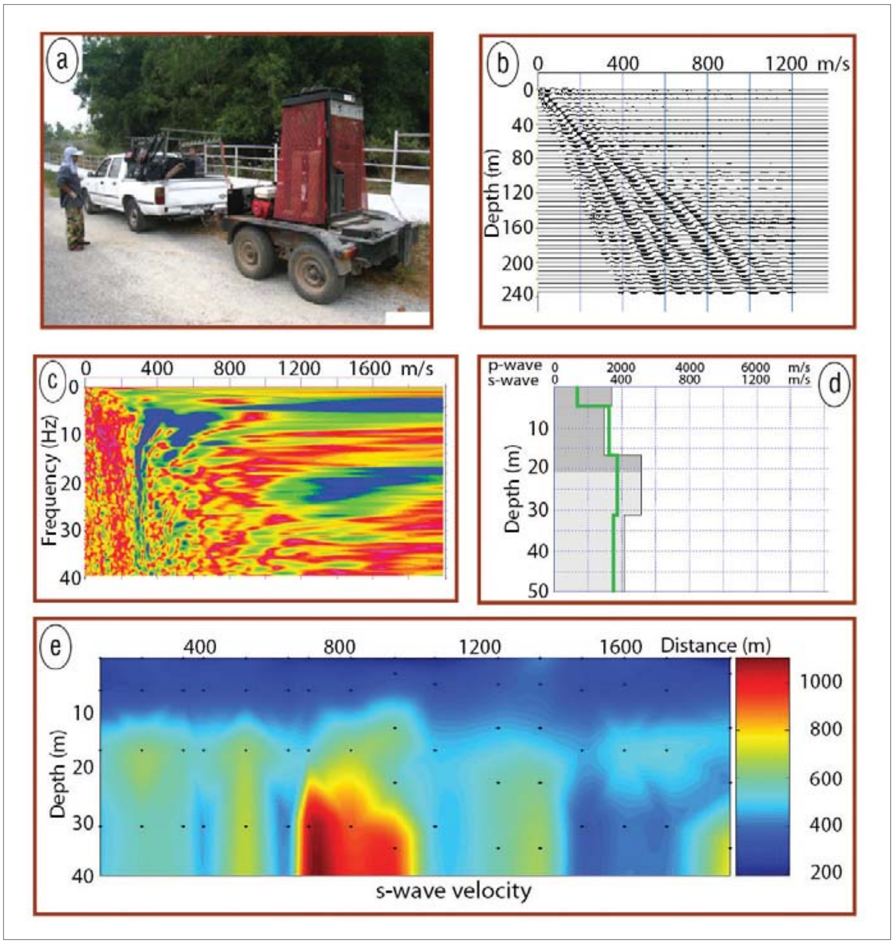

Figure 4. *(a) Seismic source used for MASW, refraction, and reflection acquisition; (b) seismic shot gather used for MASW analysis; (c) dispersion curve comparing phase velocity and frequency; (d) P-wave (green) and S-wave (gray) velocity profile derived from dispersion curve for the upper 50 m; (e) S-wave velocity profile from MASW records at Mae Hia.*

marine strata, and identify fault locations that may pose risks to northern Thailand. These data will be integrated into a regional database to improve the hazard assessments for earthquake damage from regional events. GWB participants are continuing the use of MASW and other geophysical methods for related hazards studies using the knowledge and methods from the field school.

Archaeology studies

Wiang Kum Kam, a 13th-century settlement in the Chiang Mai region, was abandoned due to repeated floods of the Ping River. After the establishment of Chiang Mai, Wiang Kum Kam continued to exist as a satellite town to the new Lanna capital until the end of the Mangrai Dynasty. Archaeological remains, such as stone tablets with Mon inscriptions, pottery, and earthenware molds have been excavated at sites around Wiang Kum Kam over the past 20 years; however, the extent of the city walls and structures is unknown (e.g., Wood et al., 2004).

Participants acquired ground-penetrating radar, magnetic, and resistivity data to identify and characterize abandoned channels of the Ping River and old temple brick walls (Figure 5). Geophysical surveys were carried out above known brick walls and where additional walls were suspected. In addition to tracking buried walls using geophysical methods, an old levee system was identified and characterized using ground-penetrating radar and resistivity results (Hinz et al., 2010). Our survey was the first documented high-resolution geophysical survey of a levee system that defines the extent of the ancient city of Wiang Kum Kam.

Wat Pan Sao is the site of a present-day temple within Chiang Mai where ancient walls and structures were unearthed during excavation (Figure 2). At this second archaeology field site, participants identify modern utilities using ground-penetrating radar or magnetic data acquired within the temple grounds along with geophysical anomalies that may represent historical features of significance. Additionally, we identified buried walkways or walls from a seismic survey, using both seismic reflection and refraction results (Hinz et al., 2010). As a result of our study, archaeologists have gained new insights into the Wat Pan Sao temple grounds and have identified sites that may warrant further study. Additionally, we are exploring new geophysical methods and procedures to work in areas of extensive cultural noise.

Data analysis

After completion of the field phase, participants focus their efforts on the analysis of geophysical data from each site. Analysis and interpretation take place at the Geological Sciences Department of Chiang Mai University. Here, we divide participants into groups. Each group works on geophysical theory, field methods, and interpretation for seismic, potential fields, resistivity, electromagnetic, and ground-penetrating radar data, to prepare incremental oral reports to the other participants. Much of the data analysis is performed using free and/or readily available software so that each participant can analyze the data sets without commercial restrictions. A team also works on data archival and data and report integration. Participants present the results to the Chiang Mai University communities and prepare a final integrated report that is available to the science and local community. Field data, processed results, field photos, methods, publications, and public domain software from the field camp are posted at *http://cgiss.boisestate.edu/gwb*.

Summary

Training directed toward student and geoscience professionals has resulted in an increased use of field-based geophysics throughout Southeast Asia. Our GWB-funded project provides a mechanism to link personnel, geophysical equipment,

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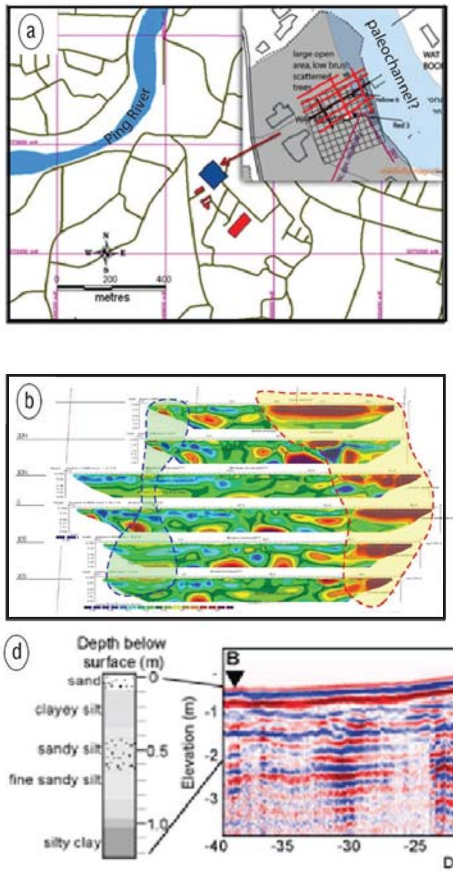

Figure 5. *(a) Site map for Wiang Kum Kam showing Ping River, and a network of modern roads and buildings. Inset map shows survey and location of paleochannel that likely influenced the partial burial of Wiang Kum Kam. (b) Parallel resistivity profiles showing lateral contrasts in the coarse- and fine-gained sediments along the paleo-Ping River channel. Resistive river sands contrast overbank deposits of the Ping River. (c) Seismic refraction profile showing low-velocity unsaturated channel deposits contrasting with the saturated fine-grained overbank deposits. (d) Ground-penetrating radar profile showing a levee separating coarse- and fine-grained deposits of the paleo Ping River channel.*

and expertise together for an intensive two-week training to address groundwater, archaeology, and geohazards problems. The skills that were learned and refined during these trainings are having a lasting impact throughout the region via student theses and professional projects that are currently underway. Additional training is scheduled beyond GWB support where new surveys will benefit not only geophysics participants but also the wider community through an increased understanding and focus on archaeological sites, groundwater infrastructure, and hazard assessments. TLE

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