Seismic imaging to help understand and manage water quality in coastal
Bénin, West Africa
Interim Project Report
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Summary of Project
The coastal city of Cotonou in Bénin, West Africa, is a large population center that is facing a serious threat to the sustainability of its fresh water supply. Cotonou is Bénin's largest city with approximately 1.5 – 2.0 million people. It relies on the Godomey aquifer for domestic water supply. The aquifer is undergoing saltwater intrusion and this problem is likely to worsen without significant steps to improve management of the water supply. The continuity of the aquifer and saltwater flow paths are poorly understood but this information is critical to ensure sustainable access to fresh water in this growing urban center. In this project, we are using seismic reflection to map the primary hydrogeologic units of the Godomey aquifer system. Additionally, we are utilizing electrical and electromagnetic methods in an effort to directly image the fresh water saltwater contact in the vicinity of the well field. The two geophysical methods together will provide information that can be integrated directly into the hydrogeologic model and improve the city’s groundwater management strategy. This work will have a number of important benefits, both direct and indirect including: Development of a high-quality aquifer map for use by the water agencies of Benin in the management of the domestic water supply for the city of Cotonou, integrating undergraduate and graduate students from Africa, the US, and Europe directly into international field work, and technology exchange among the three partner schools and the Benin government agency.

Progress since last report
This is the first interim report of the project. Since the project began we have reached all major milestones on schedule as outlined in our project timeline that was included in the original proposal.

The first project task was recruiting a graduate student. The BSU graduate student, Kyle Lindsay, was recruited soon after award notification was made and began his graduate coursework in August of 2012.

From January-February, 2013 we conducted our first field season in Bénin. Work consisted of land seismic reflection acquisition along a set of 11 profiles that ranged in length from < 200m to greater than 1.5 km. The profile layout differed from the original proposal because of complicated logistics in this congested urban area. Road surfaces were highly variable and many were not amenable to planting geophones. Heavy traffic and the associated safety concerns for the seismic crew further limited our seismic coverage. Where seismic acquisition was feasible, the roads typically ran through crowded neighborhoods with many road side shops along with heavy foot and vehicle traffic. These challenging conditions led to a change of strategy from our original proposal where we planned to do fewer but longer continuous
transects. Instead, we decided to focus our efforts on maximizing the density of coverage between the Godomey well field and the capture zone at the south west corner of Lake Nokoué. Overall, data quality was excellent and is enabling a relatively detailed interpretation of the aquifer architecture.

Our initial findings show one or more paleochannels that cut through multiple aquifer/aquitard units in several locations between the lake and the well field creating a complicated system of interconnected aquifers. This finding differs substantially from the current hydrologic model which assumes continuous, isolated aquifers. However, our seismic interpretation is consistent with recent hydrologic data which suggest that the confined aquifers are responding to changing pumping pressures in concert indicating a connected system.

In addition to the scientific objectives of our field project, we completed the following activities: 1) conducted a two day short course on shallow seismic reflection for students at the Université d’Abomey-Calavi. Over 25 UAC students participated in the short course and then were able to contribute to the subsequent field data acquisition effort. 2) We presented our initial findings at the 2013 SEG annual meeting and at the 2013 SAGA conference in South Africa. 3) Students who participated in the first field deployment gave a public presentation on the project at Boise State University in April of 2013.

Finally, we have been able to secure significant in-kind financial support from a number of organizations that include, Boise State University, University of Nice, Delta Airlines, Micron, Mala Geosciences, and the Boise State Geophysics Club –an SEG student chapter.

**Anticipated actions until next report**

There are three primary objectives to be completed during the next reporting period. First, as of this writing we are beginning our second field deployment during October of 2013. This second field effort will focus on marine seismic reflection within Lake Nokoué, altering our electrical surveying strategy, filling in a gap in our land seismic data coverage, and conducting a 3D short course in Bénin which will be expanded to include ground-penetrating radar.

The second major effort during the upcoming reporting period will be extracting geostatistical information from the seismic reflection images which will be used to inform the hydrologic model. The BSU student Kyle Lindsay will travel to Lausanne, Switzerland to work with Dr. James Irving, an expert in the area of geostatistical inversion of reflection data. Because we could schedule this trip on the return leg of the Bénin field deployment, it comes at no additional cost to the project and takes the place of an originally schedule trip to the University of Notre Dame. This change was motivated by collaborator Steve Silliman’s change of institutions from Notre Dame to Gonzaga just before the project began.

The third objective for the upcoming reporting period will be integrating seismic interpretations into the hydrologic model. BSU student Kyle Lindsay will work with two undergraduate students from Gonzaga to carry out this critical component of the project under the supervision of Dr. Bradford and Dr. Silliman. The results of this work will be integrated into the Bénin water agency’s management plan.

**Problems Encountered**

The primary problem encountered thus far has been the substantially greater level of urbanization in the work area than originally anticipated. For seismic acquisition this required reconfiguration of the survey lines. However, for the electrical and electromagnetic surveys the effects were far more detrimental. Given that the available electrical surveying equipment was
not adequate to reach the depths necessary to identify the saltwater/freshwater interface, we chose to conduct TEM measurements. Unfortunately the high level of cultural noise rendered these data useless. In our second field season we will reconfigure the electrical system to make deep 1D DC resistivity soundings which should be less sensitive to the cultural noise.

A second, but less significant difficulty has been the language barrier since very little English is spoken in Bénin. All students and faculty working on the project from outside of Bénin were required to take substantial language training prior to working in the country and this effort proved beneficial in interactions with students, faculty, and locals in Bénin.