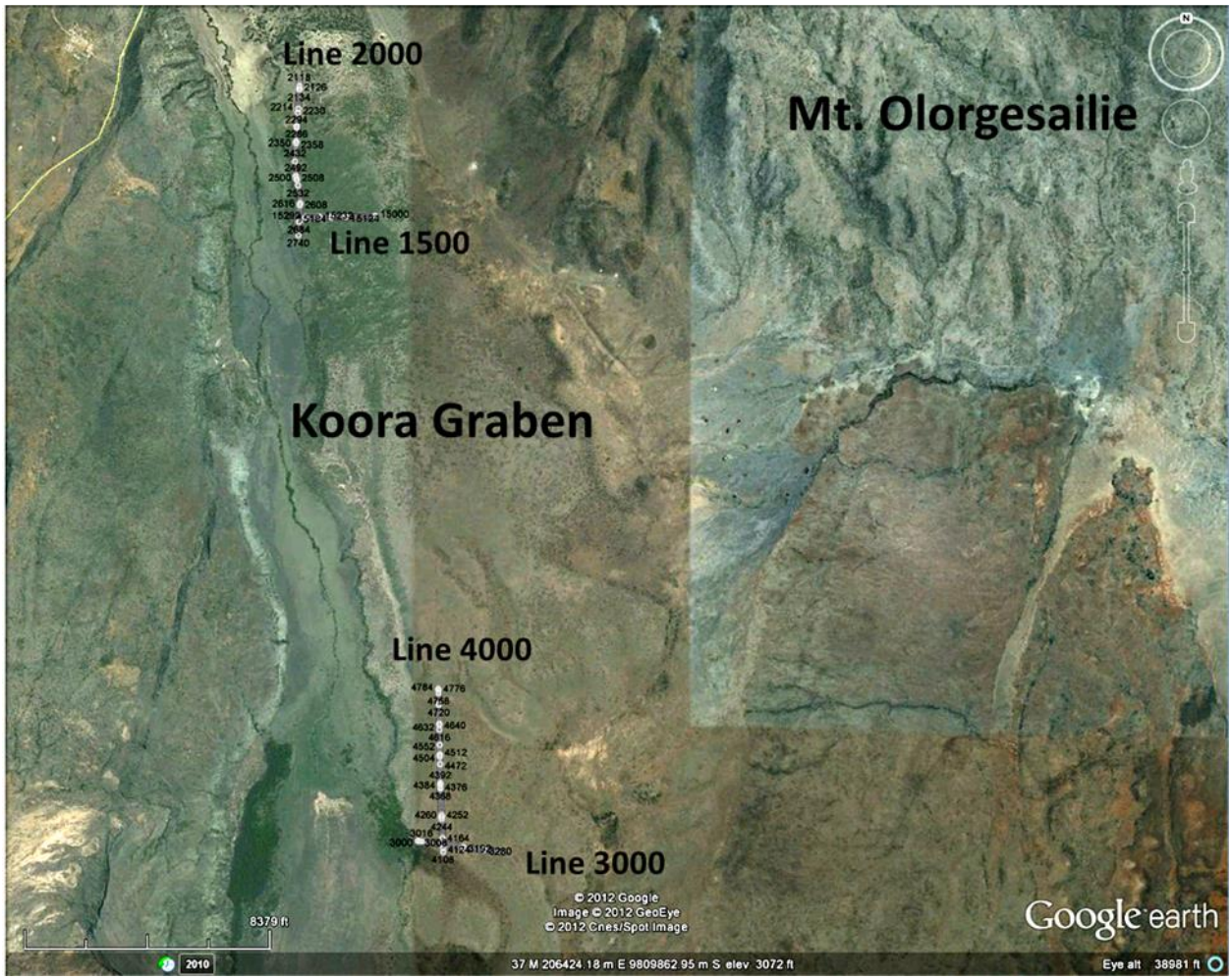
Seismic Investigation of Proposed Scientific Drilling Sites in the Southern Kenya Rift: Olorgesailie Basin (Koora Graben) High-Resolution Seismic Survey

PI: Dr. Roy A. Johnson
University of Arizona

Experiment Description

This experiment was designed to acquire relatively high-resolution 2-D multichannel seismic reflection data to help characterize the thickness and structure of lacustrine sedimentary rocks adjacent to, and south of, Mt. Olorgesailie in the Koora graben, southern Kenya.

Seismic data were acquired along four profiles in two different areas of the Koora graben (Fig. 1). The areas selected for seismic acquisition were based on previous geophysical work



(magnetic profiling) in 2009 by Dr. John Githiri (University of Nairobi), which suggested thicker sedimentary deposits in those areas. In each of the two focus areas, two intersecting linear seismic reflection transects were acquired in roughly N-S and E-W orientations using a PEG-40kg Propelled Energy Generator seismic source. The source energy was recorded into 72

receiver channels for each source impact. Between 5 and 10 source impacts at each source location were summed during recording to produce each shot record. Receiver-station (geophone) spacing used in the acquisition phase of the experiment was 2.5 m, and normal source-station spacing was 5 m. Field acquisition parameters were determined by tests in the field at the beginning of the project to produce the best results under extant conditions.

Data Acquisition Parameters

Recording Equipment:

- 24-Channel Geode dataloggers, 3 Geodes used, total 72 channels. Geode dataloggers acquire 24-bit data after analog-to-digital conversion
- PC compatible software interface/controller
- 72 Single L-40 40-Hz geophones (plus spares) manufactured by Mark Products. These vertical geophones are critically damped at 0.555 and have a sensitivity of about 21 V/m/s. Frequencies below 40 Hz are strongly attenuated (used to reduce strong ground-roll noise)

Energy Source:

- PEG-40kg Propelled Energy Generator manufactured by R.T. Clark Companies, Inc. This source operates by propelling a ~40 kg mass onto a base plate (on the ground) using large elastic bands to increase delivery force. In tests by IRIS/PASSCAL, this source delivered around 25,000 pounds of force per impact.
- For each source position, 5 to 10 impacts were summed to produce 1 shot record.

Recording Geometries Lines 1500, 2000, 3000, 4000

Lines 1500 and 2000 were acquired in the northern part of the Koora Graben, west-southwest of Mt. Olorgesailie. Data acquisition tests were performed on the first data of field work to establish source and receiver spacing and other acquisition parameters. Initial receiver spacing was 5 m for these tests, but evaluation of the test data in the field suggested that a closer spacing would provide better near-surface results. Line 1500, the first production profile, was acquired in the same location as Line 1000. Stations were renumbered in processing to accommodate the closer source and receiver spacings. Line 1500 extended from W to E and Line 2000 extended from N to S; intersection of the two lines was near the western end of Line 1500 (intersection ~ Station 15026) and the southern end of Line 2000 (intersection ~ Station 2666).

Lines 3000 and 4000 were acquired about ~6 km to the south of the northern profiles in a broader plain just east of the Koora River drainage. Intersection of the two lines was near the western end of Line 3000 (intersection at ~ Station 3104) and the southern end of Line 4000 (intersection ~ Station 4138).

Line 1500 Endpoints (UTM 37M)

- Station 15000: 209329.0 E, 9808262.9 S
- Station 15344: 210187.1 E, 9808280.7 S

Line 2000 Endpoints (UTM 37M)

- Station 2100: 209399.0 E, 9809673.0 S
- Station 2748: 209384.2 E, 9808063.4 S

Line 3000 Endpoints (UTM 37M)

- Station 3000: 210635.6 E, 9801820.0 S
- Station 3366: 211539.9 E, 9801698.7 S

Line 4000 Endpoints (UTM 37M)

- Station 4100 210900.8 E, 9801688.7 S
- Station 4796 210843.6 E, 9803416.6 S

Station Spacing

- Nominal station spacing = 2.5 m. Stations were chained with alternate stations flagged and labeled; intermediate stations were interpolated (placed midway between flags). Station locations were surveyed using a theodolite and tied to local base stations established by GPS to determine UTM coordinates.

Source Spacing

- Nominal source spacing = 5.0 m. Because the PEG-40kg source was mounted on the rear of a vehicle, the source was offset ~1 to 3 m perpendicular to the lines to avoid cable and equipment damage. In some cases, greater offsets were necessary to avoid obstacles.

Seismic Data

Shot records for each of the four profiles are consolidated into SEG-Y-format files.

Line 1500: 174 Shots; Field File IDs (FFIDs) 15001-15045, 15049-15177.
Line 2000: 326 Shots; Field File IDs (FFIDs) 20001-20138, 20142-20172, 20174-200.
Line 3000: 184 Shots; Field File IDs (FFIDs) 30001-30125, 30127-30185.
Line 4000: 349 Shots; Field File IDs (FFIDs) 40001-40349.

The individual records have geometry information entered in the trace headers with entries as shown in the SEG-Y EBCDIC header (example below). Each SEG-Y file contains all shot records for a particular line.

Example EBCDIC header:

C 1 University of Arizona, Reflection Seismology
C 2 LINE: 2000 AREA: Olorgesailie, Kenya MAP ID: UTM 37M
C 3 INSTRUMENT: 24-Channel Geometrics Geode Systems from PASSCAL
C 4 DATA TRACES/RECORD: 72
C 5 SAMPLE INTERNAL: 0.25 ms SAMPLES/TRACE: 4001
C 6 RECORDING FORMAT: SEGY MEASUREMENT SYSTEM: Meters
C 7 SAMPLE CODE: IBM REAL GAIN TYPE: FIXED

C 8 FILTERS: LO-CUT: 35 Hz
C 9 SOURCE: PEG-40Kg Weight Drop, 5 to 9 Hits SP-INTERVAL: 5 m
C10 SPREAD: Channels 1-72 GROUP INTERVAL: 2.5 m
C11 GEOPHONES/GROUP: 1 FREQ: 40 Hz MFG: Mark Prod. MODEL: L-40
C12 MAP PROJECTION: UTM ZONE ID: 37M COORDINATE UNITS: Meters
C13 LINE START COORDS: Station 100: 209399.0 E, 9809673.0 S
C14 LINE END COORDS: Station 748: 209384.2 E, 9808063.4 S
C15 TRACE HEADERS BELOW: Header, Format, Start Byte
C16 Trace sequence number in line: Int (4-byte) Start: 1
C17 Trace sequence number in SEG Y file: Int (4-byte) Start: 5
C18 Original field record number (FFID): Int (4-byte) Start: 9
C19 Trace number in original field record: Int (4-byte) Start: 13
C20 Energy source point number: Int (4-byte) Start: 17
C21 CDP ensemble number: Int (4-byte) Start: 21
C22 Trace identification code (1 = data): Int (2-byte) Start: 29
C23 Number of source impacts this trace: Int (2-byte) Start: 33
C24 Distance source point to receiver: Int (4-byte) Start: 37
C25 Receiver elevation: Int (4-byte) Start: 41
C26 Surface elevation at source: Int (4-byte) Start: 45
C27 Scalar for elevations in bytes 41-68: Int (2-byte) Start: 69
C28 Scalar for coords in bytes 73-88 and 181-188: Int (2-byte) Start: 71
C29 Source coordinate – X (times 10000): Int (4-byte) Start: 73
C30 Source coordinate – Y (times 10000): Int (4-byte) Start: 77
C31 Group coordinate – X (times 10000): Int (4-byte) Start: 81
C32 Group coordinate – Y (times 10000): Int (4-byte) Start: 85
C33 Number of samples in trace: Int (2-byte) Start: 115
C34 Sample interval in microseconds (us): Int (2-byte) Start: 117
C35 Low-cut frequency (Hz): Int (2-byte) Start: 149
C36 X coordinate of CDP position of trace: Int (4-byte) Start: 181
C37 Y coordinate of CDP position of trace: Int (4-byte) Start: 185
C38 Shot-point number: Int (4-byte) Start: 197
C39 SEG Y REV1
C40 END EBCDIC