FINAL TECHNICAL REPORT

U.S.G.S. National Earthquakes Hazards Reduction Program

PALEOSEISMOLOGY OF THE EAST GREAT SALT LAKE FAULT*

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Program elements: "Evaluate Urban Hazard and Risk" for "Other regions of the United States": "Determine recurrence intervals, slip rates, and segmentation characteristics of poorly studied active faults that directly affect the hazard in highly populated urban areas"
Key words: Paleoseismology, Recurrence interval, Neotectonics, Reflection seismology

Nontechnical Summary

Geophysical imaging methods analogous to sonar were used to study the East Great Salt Lake fault, a major active extensional fault submerged beneath the Great Salt Lake. Sound waves generated from devices towed behind a small boat reflect back from layers of sediment beneath the lake floor and are recorded on thermal paper and digital media. Images formed from these echoes provide cross sections of layers disrupted by modern faulting, and enabled us to accurately map the East Great Salt Lake fault beneath the lake south of Promontory Point, to identify evidence for at least six large (M 6.8-6.9) prehistoric earthquakes on the fault, and to estimate that such earthquakes occur approximately every 2,250 years. Our work indicates that the East Great Salt Lake fault poses a major earthquake risk to the Ogden-Salt Lake City-Provo urban corridor.

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TECHNICAL ABSTRACT

High resolution seismic reflection profiles acquired from the Great Salt Lake in September, 1998, provide evidence of multiple Holocene earthquakes on the East Great Salt Lake fault (EGSLF), as well as detailed images of the near-surface geometry of this and related subsidiary faults. A new active fault map of the east central Great Salt Lake basin made from these data shows (1) a 2-km left step in the active trace of the EGSLF west of northern Antelope Island that separates the fault south of Promontory Point into two NNW-striking segments: a 35-km-long Antelope Island segment and a 30-km-long Fremont Island segment, (2) that the Antelope Island segment bends sharply southwestward near its southern end, possibly transferring displacement into the Oquirrh fault zone, and (3) that the hanging wall of the EGSLF is itself extending on numerous active normal faults. Stratigraphic and structural geometries including auxiliary faults, tectonically produced angular unconformities and onlap surfaces in hanging-wall strata adjacent to the EGSLF preserve evidence of at least three seismogenic slip events each on the Fremont and Antelope Island segments of the fault since the end of the Bonneville highstand ~13,000-14,000 calendar years B.P., and of an early or mid-Holocene period of desiccation and subaerial erosion during which debris flow fans accumulated at the base of the EGSLF scarp. Evidence of repeated large surface offsets in Holocene time, a preserved scarp with 3 meters of relief at the lakebed west of Antelope Island, and an association with auxiliary faults that cut the lakebed in areas of active sedimentation indicate that the EGSLF is active and capable of producing large earthquakes in the heavily populated Ogden-Salt Lake City urban corridor. For the observed segment lengths, empirical relationships for normal faults (Wells and Coppersmith, 1994) imply events in the range M6.8-6.9. Our current best estimate of the recurrence interval of such events on each of the two EGSLF segments south of Promontory Point is 4500 (+1100/-736) years.

INTRODUCTION AND PREVIOUS WORK

The west-southwest dipping East Great Salt Lake fault (EGSLF) lies submerged beneath the Great Salt Lake 30-65 km west of the subparallel Wasatch fault and the Ogden-Salt Lake City metropolitan areas (Fig. 1). Multichannel seismic reflection profiles reveal the EGSLF as a major normal fault bounding a large Cenozoic half graben that underlies the lake (Mikulich and Smith, 1974; Smith and Bruhn, 1984; Bortz et al., 1985; Viveiros, 1986; Mohapatra and Johnson, 1998). The deepest part of the half graben contains >3500 meters of Neogene-Quaternary sedimentary strata (Mikulich and Smith, 1974; Bortz and others, 1985; Viveiros, 1986), indicative of major subsidence during the past 24 m.y. The Promontory Mountains and Fremont and Antelope Islands rise up to 800 meters above the lakebed immediately east of the EGSLF, attesting to major isostatic rebound of the fault's footwall. Well data and high-resolution seismic reflection profiles (Mikulich and Smith, 1974; Viveiros, 1986; Colman and Kelts, 1997) show that the EGSLF displaces Holocene lake deposits.

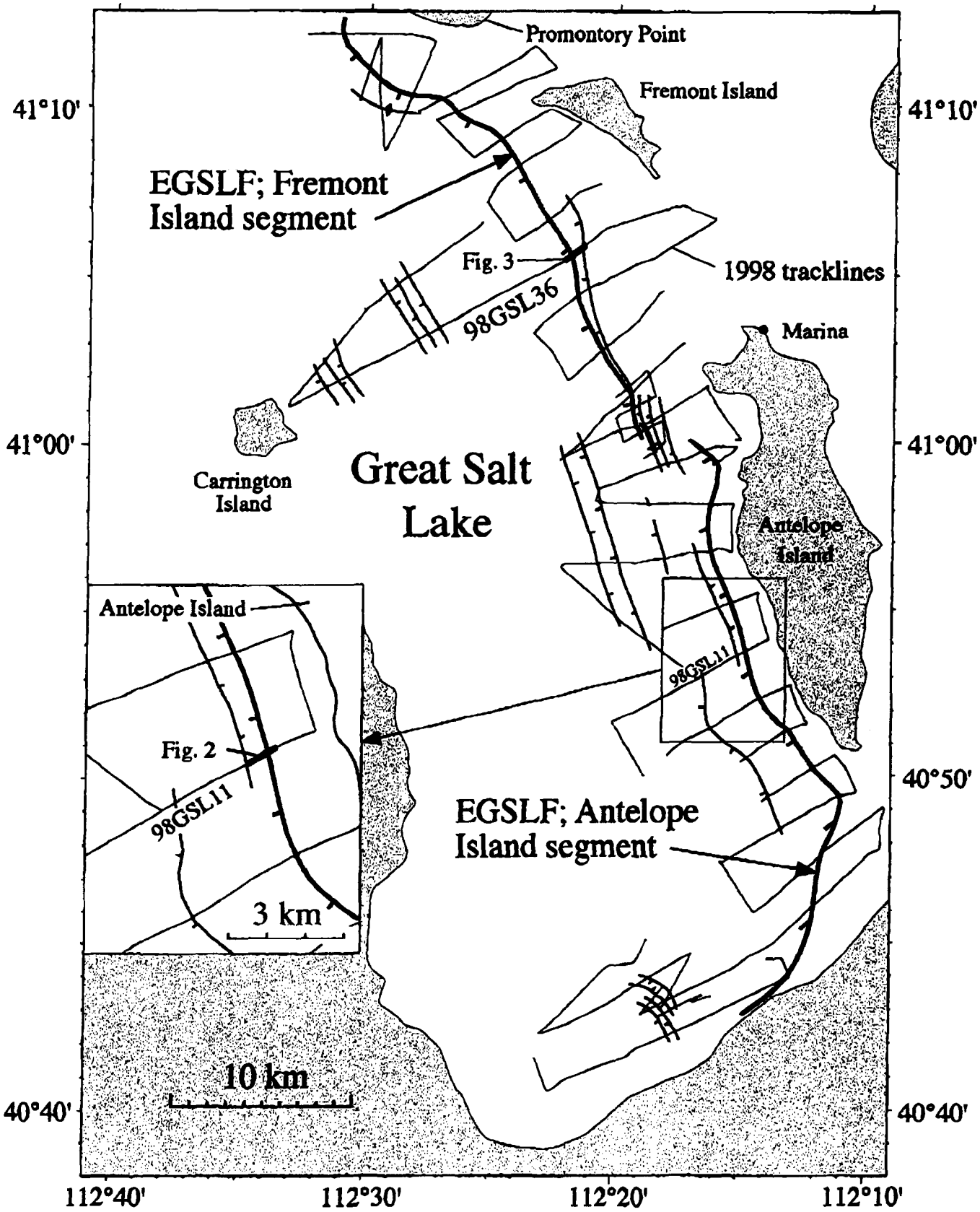

Figure 1. Location map showing University of Utah 1998 Great Salt Lake high-resolution seismic reflection tracklines, East Great Salt Lake fault (EGSLF), and related active normal faults profiled in 1998 survey. Note segment boundary in EGSLF west of northern Antelope Island and abrupt westward bend in southern segment near southeast lake shore. Inset shows segment of Line 98GSL11 illustrated in Fig. 2.

The EGSLF is similar in size and tectonic setting to other active normal faults in the Intermountain Seismic Belt. Paleoseismic studies of the Wasatch fault (e.g., McCalpin and Nishenko, 1996) and historical seismicity on normal faults along the eastern margin of the Great Basin (e.g., the 1959 M_w 7.3 Hebgen Lake, Montana and 1983 M_w 6.9 Borah Peak, Idaho events) show that such faults generate maximum earthquakes in the range M_w 6.9-7.5 (Machette et al., 1991; Wong et al., 1995; Mason, 1996). The goal of the present study is to directly assess the seismic hazard posed by the EGSLF to the Ogden-Salt Lake City urban corridor (pop. >1 million). Our integrated reflection seismic-coring approach to this problem is conceptually analogous to a trenching exercise: Using high-resolution seismic reflection profiles we acquired in 1998, we have mapped the EGSLF and subsidiary structures in detail and characterized stratigraphic and structural geometries that are directly attributable to Quaternary surface offsets on the EGSLF (e.g., bed rotations, angular conformities, offsets on auxiliary faults). These results are summarized below. In the second component of the study (funded by NEHRP for 2000-2001), we will identify and radiometrically date key horizons in cores adjacent to the fault to determine the recurrence intervals of major earthquakes on both the Fremont and Antelope Island segments of the EGSLF. The cores to be studied were obtained in a highly successful NSF-funded drilling program mounted August 9-September 4, 2000 (Dinter et al., 2000).

RESULTS

Data collection: We acquired ~325 kilometers of high-resolution seismic reflection data from the southwestern Great Salt Lake basin during the period September 9-18, 1998, including 31 crossings of the East Great Salt Lake fault and related subsidiary faults west of Antelope and Fremont Islands, between Promontory Point and the south shore marina (Fig. 1). Sources and hydrophones were towed from the Antelope Island State Park patrol-and-rescue boat, a 27-foot Boston Whaler with twin 250-hp outboards. Lake level during the survey was 1281 m (4202 ft). Profiles were obtained in water depths of 2-10 m at speeds ranging from 6-8 km/hr, depending on weather conditions. A 12-channel Trimble ProXR GPS mapping system was employed both for real-time navigation accurate to ±60 m, and to acquire trackline position data, which were differentially corrected using data from the Utah County GPS base station in Provo, UT to provide submeter accuracy. Seismic and navigation systems were powered by a 3500-watt generator.

Two seismic systems were operated simultaneously, a high-frequency Datasonics Chirp II subbottom profiler and a Geopulse boomer profiler, towed from opposite sides of the survey vessel and triggered at identical 0.5-sec intervals. Data from both systems were printed on thermal paper in real time using an EPC graphics recorder, and were also recorded in modified SEG-Y format on 2-Gb Jaz disks via the Chirp II acquisition-processing unit. Chirp transducers and hydrophones are housed in a single towfish, which was towed ~1 meter beneath the lake surface from a 6-foot davit with a hand-cranked winch. Transducers were configured to sweep a 2-7-kHz frequency range in 0.005 s, typically producing (at maximum gain) good images of unconsolidated lake sediments as deep as 15-20 m below the lakebed, assuming a velocity of 1500 m/s. Concentrations of biogenic gas in the sediment degraded Chirp profiles locally.

The Geopulse boomer plate assembly, bolted to a small polystyrene surfboard, was towed close to the hull ~0.25 m below the lake surface. Most of the source energy is produced in the 800-3000 Hz frequency range. Operating at 200 Joules, this system commonly imaged strata to 75 m below the lakebed, exceptionally as deep as 150 m. The hydrophone streamer was towed ~2 m forward of the source, also at ~0.25 m water depth, from a boom lashed to the bow. Geopulse data were locally degraded by biogenic gas, but less severely than the Chirp records.

Analysis: High-resolution seismic reflection profiles obtained in our 1998 survey allowed us to map the active trace of the EGSLF and related structures with much greater accuracy and detail than was previously possible with industrial multichannel air-gun and sparker records (Fig. 1) (cf.

Mikulich and Smith, 1974; Viveiros, 1986). In addition, the high-resolution profiles provide extraordinarily detailed images of stratigraphic and structural geometries near the EGSLF that are directly related to major seismogenic offsets on that structure (Figs. 2 and 3).

The uppermost stratigraphic unit sampled in shallow cores from the Great Salt Lake south of Promontory Point is a poorly consolidated mud, silt, and fine-sand, ooid-bearing stratum ~2-16 m thick (Unit I of Spencer et al., 1984; more comprehensively sampled in a recent coring program summarized in Dinter et al., 2000), which represents essentially modern shallow lake conditions that have persisted with intermittent fluctuations for the last 11,000-12,000 years. Unit II, a fine-grained organic-rich layer ~0.5 m thick underlying Unit I, was deposited in a lake shallower than at present during a brief period immediately following the abrupt lowering of glacial Lake Bonneville from its Provo-level stillstand. A massive fish die-off corresponding to this post-Provo depression of lake level occurred at 11.2-11.3 ^{14}C ka B.P. (Madsen et al., 2000). For purposes of the preliminary analyses presented in this report, we have assumed that deep Lake Bonneville deposition ended in the interval 11-12 ^{14}C ka B.P., or ~13,000-14,000 calendar years B.P. (Stuiver et al., 1998). Unit III of Spencer et al. (1984), ~2-3 m thick, represents deep-water deposition in Lake Bonneville during the last glacial maximum (oxygen isotope stage 2).

The uppermost seismostratigraphic unit imaged in our high-resolution reflection profiles – informally designated "Unit A" in this report – is a nearly transparent acoustic unit containing weak, laterally persistent internal reflectors (Figs. 2 and 3). Based on a tentative correlation with Core C of Spencer et al. (1984), acoustic Unit A may comprise both core Units I and II. Unit A overlies a distinctly bedded acoustic unit at a strongly reflective horizon, H_0, prominent throughout the Great Salt Lake basin. Unit A is wedge-shaped, thickening eastward from 2-3 m off Carrington and Stansbury Islands to as much as 16 m adjacent to the EGSLF (Figs. 2 and 3) (Dinter and Pechmann, unpublished data).

Active fault geometries in southwestern Great Salt Lake basin

Active faults in the central Great Salt Lake basin profiled in our 1998 survey are illustrated in Fig. 1. Nearly all of these structures are normal faults showing clear evidence of increasing offset with depth ("growth") in the seismic records. The criterion for "active" on this map is that each fault portrayed cuts reflector H_0, the base of Unit A. In fact, many of the faults shown cut entirely through Unit A and have scarps at the lakebed. Despite exceptionally high Holocene depositional rates in the trough adjacent to the fault, preserved relief on the EGSLF scarp west of central and southern Antelope Island is as great as 3.3 meters (Fig. 2).

The active strand of the EGSLF south of Promontory Point consists of two NNW-striking segments, separated by a 2-km left step west of Antelope Island. The stepover zone comprises an array of small west-dipping normal faults that may propagate outward into the basin (Fig. 1). The southern (Antelope Island) segment is ~35 km long; it bends sharply to the southwest south of Antelope Island and appears to transfer displacement into the Oquirrh fault system. A cluster of normal faults with lakebed offsets as great as several meters near the south lake shore is probably related to this transfer zone. The northern (Fremont Island) segment of the EGSLF is ~30 km long; it appears to terminate near Promontory Point, yielding through another stepover zone of unknown geometry to a third (Promontory) segment to the north.

The hanging wall of the EGSLF is itself extending, accommodated by numerous synthetic normal faults and by at least four actively subsiding grabens 1-2 km wide with axes parallel to the EGSLF in the central basin of the Great Salt Lake (Fig. 1). Displacement on these structures may account for some of the "missing strain" in the Wasatch Front region; that is, for the discrepancy between the horizontal spreading rate determined by GPS measurements and the significantly smaller rate attributable to slip on known active faults (Martinez et al., 1998; Pechmann, 1998).

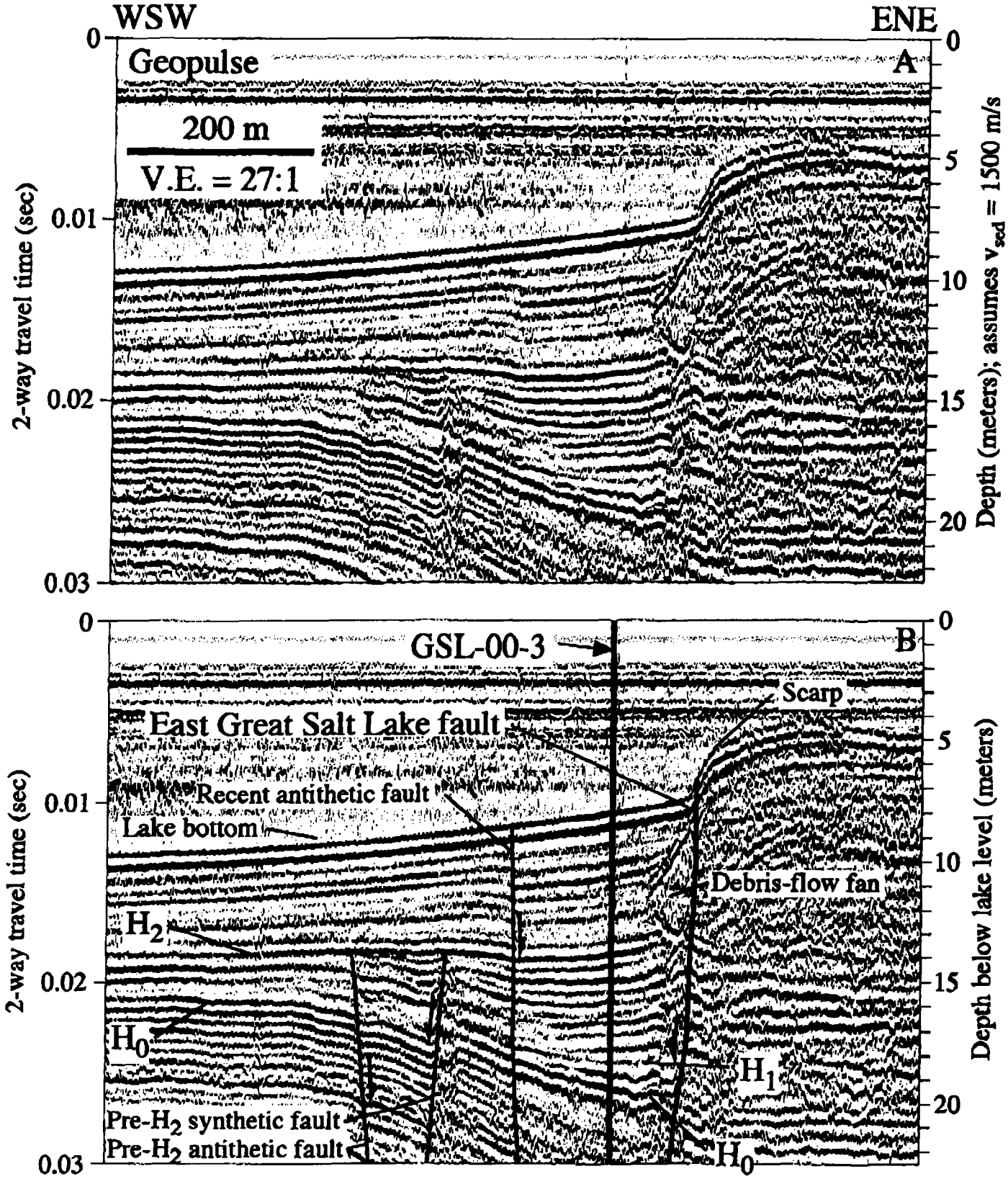

Fig. 2. Tectonostratigraphy and core site GSL-00-3 in hanging wall of EGSLF, Antelope Island segment, Geopulse Line 98GSL11 (Dinter and Pechmann, 1999). V.E. = 27:1. See Fig. 1 for location. A - Uninterpreted profile. B - Interpreted profile showing EGSLF and subsidiary normal faults in hanging wall, disconformity H_0 (base of modern lake deposits), H_1 onlap surface, erosional angular unconformity H_2, and middle Holocene debris-flow fan. See text for further discussion.

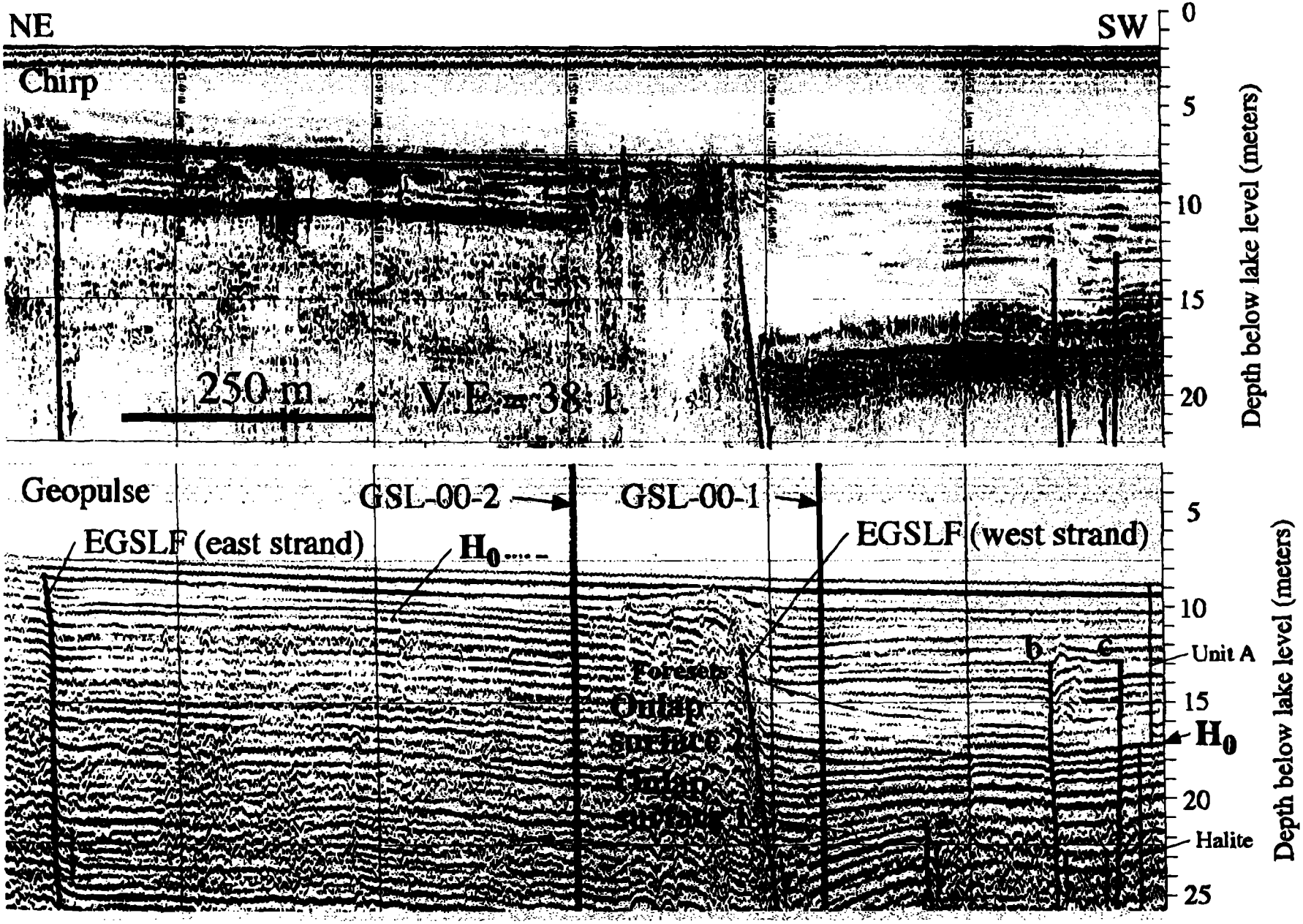

Fig. 3. Tectonostratigraphy and core sites GSL-00-1 and GSL-00-2 in hanging wall and footwall, respectively, of west strand of EGSLF, Fremont Island segment, Line 98GSL36 (Dinter and Pechmann, 1999). V.E.=38:1. See Fig. 1 for location. A - Chirp profile. B - Interpreted Geopulse profile. Note onlap surfaces 1 and 2 and auxiliary normal faults a, b,and c related to three successive surface ruptures on EGSLF. Disconformity H_0 represents base of modern lake deposits, underlain by 12.5-m-thick halite-sapropel sequence in hanging wall. See text for further discussion.

Stratigraphic record of paleoseismicity

Horizon H_0 at the base of acoustic Unit A is inferred to mark the onset of essentially modern shallow lake conditions after the disappearance of Lake Bonneville (see above). Structural geometries imaged within Unit A in our data preserve direct evidence of multiple post-H_0 surface-rupturing slip events on both the southern (Antelope Island) and central (Fremont Island) segments of the EGSLF. The evidence includes tectonically produced bedding rotations and onlap surfaces, angular unconformities, and stratigraphically limited subsidiary faults (Figs. 2 and 3). Stratigraphic analysis and dating of key horizons in new cores collected west of Fremont and Antelope Islands in August, 2000, will allow us to determine the surface-faulting chronology near the center of each segment. Further analysis of our existing seismic data will let us assess the variation in total slip and slip rates along the length of each segment.

Antelope Island segment: Stratigraphic geometries imaged in coincident Geopulse and Chirp profiles on Line 98GSL11 record three discrete surface ruptures on the Antelope Island segment of the EGSLF during the deposition of Unit A. H_1, an onlap surface, records an early post-H_0 slip event. H_0 and the lowermost ~1.5 m of Unit A beds up to and including H_1 dip eastward toward the EGSLF, a result of tectonic rotation of hanging-wall strata toward the fault plane ("reverse drag") (Fig. 2). All younger beds on this line dip westward. Strata deposited after the H_1 earthquake onlap surface H_1 progressively to the west. Displacements on two small auxiliary faults and an associated tilting of beds prior to the formation of angular unconformity H_2 record a second major slip event (Fig. 2). A third post-H_0 slip event must have been fairly recent, as it associated with an antithetic normal fault that cuts the lake bottom. A small graben bounded by this fault and the EGSLF is filled by ~0.5 m of sediment (Fig. 2). This last event also probably produced the prominent lakebed scarp, up to 3.3 m in height, on the Antelope Island segment.

Fremont Island segment: The Fremont Island segment of the EGSLF has two subparallel active strands that probably merge below the penetration depth of our profiles (Fig. 3). The western (basinward) strand has the greater throw. A thinned Unit A is present both on the block between the two strands and on the footwall of the eastern strand. Below Unit A in the hanging wall of the western strand, recent drilling at Site GSL-00-1 penetrated a halite and sapropel unit as thick as 13.3 m, inferred to represent an early Holocene extreme lowstand of the lake (Dinter et al., 2000). Only 10 cm of halite are present at this stratigraphic level in the hanging wall of the Antelope Island segment, emphasizing that the two segments differ in their detailed displacement histories.

Tectonostratigraphic geometries within Unit A and the underlying halite sequence on Line 98GSL36 record at least three seismogenic surface ruptures on the west strand of the Fremont Island segment (Fig. 3). The earliest event rotated halite beds below onlap surface 1 toward the EGSLF and is also associated with a small synthetic auxiliary normal fault ("a" on Fig. 3). Onlap surface 2 just below the base of Unit A adjacent to the western strand records a tectonic rotation just *prior* to end of salt deposition. Above this onlap surface ~3 meters of strata in the lower part of Unit A appear to compose a west-dipping deltaic foreset sequence that accumulated at the base of the event-2 fault scarp. A pair of small auxiliary normal faults, one synthetic ("b", Fig. 3) and one antithetic ("c", Fig. 3) to the EGSLF, that penetrate Unit A to within ~4 m of the lakebed record a third Holocene slip event, the most recent one on the western strand (Fig. 3) A post-H_0 rupture along which Unit A is deformed to within ~0.5 m below the lakebed is evident on the eastern strand of the Fremont Island segment. Analysis of cores recently collected at Sites GSL-00-1 and GSL-00-2 will directly address whether any of the events correlate between strands. The complete burial by Holocene sediment of the scarp corresponding to the latest surface rupture on the Fremont Island segment probably implies that this event significantly preceded the latest event on the Antelope Island segment, which is associated with a large modern scarp (see above).

Implications for earthquake hazards

Tables 1 and 2 below summarize our current best estimates of surface faulting characteristics and maximum magnitudes, respectively, for the EGSLF.

Average Recurrence Interval (ARI). The ARI for large earthquakes on a fault during some time period of interest is usually calculated by dividing the time interval between the first and last dated earthquakes by the number of interevent times (e.g., Machette et al., 1991, 1992). At present, we do not know the dates of any of the paleoearthquakes identified along the EGSLF. Consequently, we estimate the ARI and its uncertainties from the observations of 3 earthquakes on each segment during the interpreted post-Bonneville time interval of 13,500±500 years. The number of interevent times represented can range from 2 to 4, depending on when earthquakes occurred relative to the beginning and end of the time interval. Therefore, the ARI for each segment is given by 13,500±500 yrs / 3±1, which is 3250 to 7500 yrs. The range of these ARI estimates may be reduced somewhat by combining the observations from the Antelope Island and Fremont Island segments. If we assume that none of the post-Bonneville events on the Fremont Island segment coincided with those on the Antelope Island segment, then the composite recurrence interval for the two segments combined is 13,500±500 yrs / 6±1 = 2,250 yrs, with uncertainty limits of 1,857 to 2800 yrs. If we furthermore assume that both segments have the same ARI, then the best-estimate ARI for each of the two segments is twice the composite recurrence interval or 4500 yrs, with uncertainty limits of 3714 to 5600 yrs. This result is our preferred ARI for each EGSLF segment.

Magnitude Estimates. Moment magnitudes for prehistoric surface faulting earthquakes on the EGSLF may be estimated from interpreted surface rupture lengths and/or rupture areas using the empirical relations of Wells and Coppersmith (1994) for normal faults. For the rupture lengths, we use the straight line end-to-end segment length measurements of 35 km for the Antelope Island segment and 30 km for the Fremont Island segment for consistency with Wells and Coppersmith's measurements (Ivan Wong, personal communcation, 1994). To calculate rupture areas we assumed an average fault dip of 40 degrees based on processed Amoco seismic reflection sections in Mohapatra and Johnson (1998), and a seismogenic zone thickness of 15 km, to obtain a rupture width of 23.3 km. The empirical relations between rupture length and magnitude and rupture area and magnitude both give estimated maximum magnitudes of 6.9±0.3 for the Antelope Island segment and 6.8±0.3 for the Fremont Island segment, where the uncertainty limits given are one standard deviation (Table 2).

Table 1: Surface-Faulting Characteristics, East Great Salt Lake Fault
Note: All uncertainty limits are one standard deviation.

	Antelope Island Segment	Fremont Island Segment
Post-Bonneville Events (N)	3	3
Average Recurrence Interval (ARI) (13,500 ± ~~1~~,500 yrs / N ± 1)	3250 to ~~7500~~ 7000 yrs	3250 to ~~7500~~ 7000 yrs
Best-Estimate ARI 2 x (13,500 ± 500) / (6 ± 1)	4500 (3714 to 5600) yrs	4500 (3714 to 5600) yrs
Segment Length (straight line end to end)	35 km	30 km

- corrections via Jim Pechmann, verbal comm. to M. Hylland, 3/8/01

Table 2: Maximum Magnitude Estimates, East Great Salt Lake Fault (from empirical relationships in Wells and Coppersmith, 1994) Note: All uncertainty limits are one standard deviation.		
Faulting Parameter	Antelope Island Segment	Fremont Island Segment
Surface Rupture Length	6.9 ± 0.3	6.8 ± 0.3
Rupture Area	6.9 ± 0.3	6.8 ± 0.3

FUTURE WORK

The preliminary paleoseismicity assessment presented above is based on detailed analyses of two of the thirty-one EGSLF profiles obtained by the University of Utah in 1998 under U.S.G.S. Award Number 98HQGR1013. Processing and similar anayses in progress of additional profiles crossing both active fault segments will facilitate a more complete description of the tectonostratigraphic record of slip events. In the NEHRP-funded continuation of this study in 2000-2001, recently collected continuous cores of the hanging wall and footwall of the EGSLF will be analyzed to determine the recurrence intervals of surface-rupturing seismic events and late Quaternary slip rates on both the Fremont and Antelope Island segments of the EGSLF.

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Paleoseismology of the East Great Salt Lake Fault

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Investigations undertaken

The goal of this study is to directly assess the seismic hazard posed by the East Great Salt Lake normal fault (EGSLF) to the Ogden-Salt Lake City urban corridor (pop. >1 million). Our integrated reflection seismic-coring approach to the problem is conceptually analogous to a trenching exercise. We used high-resolution seismic reflection profiling to map the EGSLF and subsidiary structures and to characterize stratigraphic and structural geometries directly attributable to Quaternary surface offsets on the EGSLF, including bedding rotations, angular conformities, and offsets on auxiliary faults. In the second component of the study, funded by NEHRP for 2000-2001, key horizons in cores adjacent to the fault will be radiometrically dated to determine recurrence intervals of major earthquakes.

Data collection

We acquired ~325 kilometers of high-resolution seismic reflection data from the southwestern Great Salt Lake basin during the period September 9-18, 1998, including 31 crossings of the EGSLF and related subsidiary faults west of Antelope and Fremont Islands, between Promontory Point and the south lakeshore (Fig. 1). Sources and hydrophones were towed from a 27-foot Boston Whaler in water depths of 2-10 m at speeds ranging from 6-8 km/hr. Two seismic systems were operated simultaneously: a Datasonics Chirp II subbottom profiler and a Geopulse boomer profiler, towed from opposite sides of the survey vessel and triggered at identical 0.5-sec intervals. Data were printed on thermal paper in real time on an EPC graphics recorder, and also recorded in modified SEG-Y format on 2-Gb Jaz disks. Chirp transducers and hydrophones housed in a single towfish were towed ~1 meter beneath the lake surface. The transducers swept a 2-7-kHz frequency range in 0.005 s, typically producing good images of unconsolidated lake sediments as deep as 15-20 m below the lakebed. The Geopulse boomer plate assembly was towed close to the hull ~0.25 m below the lake surface and produced energy primarily in the 800-3000 Hz range. The hydrophone streamer was towed ~2 m forward of the source at the same depth. Operating at 200 Joules, this system commonly imaged strata to 75 m below the lakebed, exceptionally as deep as 150 m. A 12-channel Trimble ProXR GPS mapping system was employed both for real-time navigation accurate to ±60 m, and to acquire trackline position data that have been differentially corrected to submeter accuracy.

Results

High resolution seismic reflection profiles from the southwest basin of the Great Salt Lake provide evidence of multiple Holocene earthquakes on the EGSLF, as well as detailed images of the near-surface geometry of this fault and related subsidiary faults. A new active fault map of the south central Great Salt Lake made from these data shows that (1) a 2-km left step in the active trace of the EGSLF west of northern Antelope Island appears to separate the fault south of Promontory Point into two NNW-striking segments: a 35-km-long Antelope Island segment and a 30-km-long Fremont Island segment, (2) the Antelope Island segment bends sharply southwestward near its southern end, possibly transferring displacement into the Oquirrh fault zone south of the lake, and (3) the hanging wall of the EGSLF is itself extending on numerous active normal faults (Fig. 1). Stratigraphic and structural geometries in hanging-wall strata adjacent to the EGSLF preserve evidence of at least three surface-faulting earthquakes each on the Fremont and Antelope Island segments since the end of the Bonneville highstand ~13,000-14,000 calendar years B.P., and of an early or mid-Holocene period of desiccation and subaerial erosion during which debris flow fans accumulated at the base of the EGSLF scarp (Figs. 2 and 3). Evidence of repeated large surface offsets in Holocene time, a preserved scarp with up to 3.6 meters of relief at the lakebed west of Antelope Island, and an association with auxiliary faults that cut the lakebed in areas of active sedimentation indicate that the EGSLF is active and capable of producing large earthquakes in the heavily populated Ogden-Salt Lake City urban corridor. For the observed segment lengths, empirical relationships for normal faults imply events in the range M6.8-6.9. Our current best estimate of the recurrence interval of such events on each of the two EGSLF segments south of Promontory Point is 4500 (+1100/-786) years (Tables 1 and 2).

Table 1: Surface-Faulting Characteristics, East Great Salt Lake Fault

	Antelope Island Segment	Fremont Island Segment
Post-Bonneville events (N)	3	3
Average Recurrence Interval (ARI) (13,500±500 yrs)/(N±1 intervals)	3250 to 7000 yrs	3250 to 7000 yrs
Best-Estimate ARI* 2x(13,500±500 yrs)/(6±1 intervals)	4500 (3714 to 5600) yrs	4500 (3714 to 5600) yrs
Segment Length (straight line end to end)	35 km	30 km

* Assumes both segments have the same ARI and that all six ruptures were single-segment.

Table 2: Maximum Magnitude Estimates, East Great Salt Lake Fault
(from empirical relationships in Wells and Coppersmith, 1994, BSSA v. 84, 974-1002)
Note: Uncertainty limits are one standard deviation.

Faulting Parameter	Antelope Island Segment	Fremont Island Segment
Surface rupture length	6.9 ± 0.3	6.8 ± 0.3
Rupture area (23-km width)	6.9 ± 0.3	6.8 ± 0.3

Nontechnical summary

We used geophysical methods analogous to sonar to study the East Great Salt Lake fault (EGSLF), a major active extensional fault submerged beneath the Great Salt Lake. Images formed from sonic echoes provided cross sections of layers disrupted by faulting and enabled us to map the EGSLF south of Promontory Point, to identify evidence for six large prehistoric earthquakes on the fault (M 6.8-6.9), and to estimate that such earthquakes occur at intervals of ~2,250 years. Our work indicates that this fault poses a major earthquake risk to the Ogden-Salt Lake City urban corridor.

Publications to date

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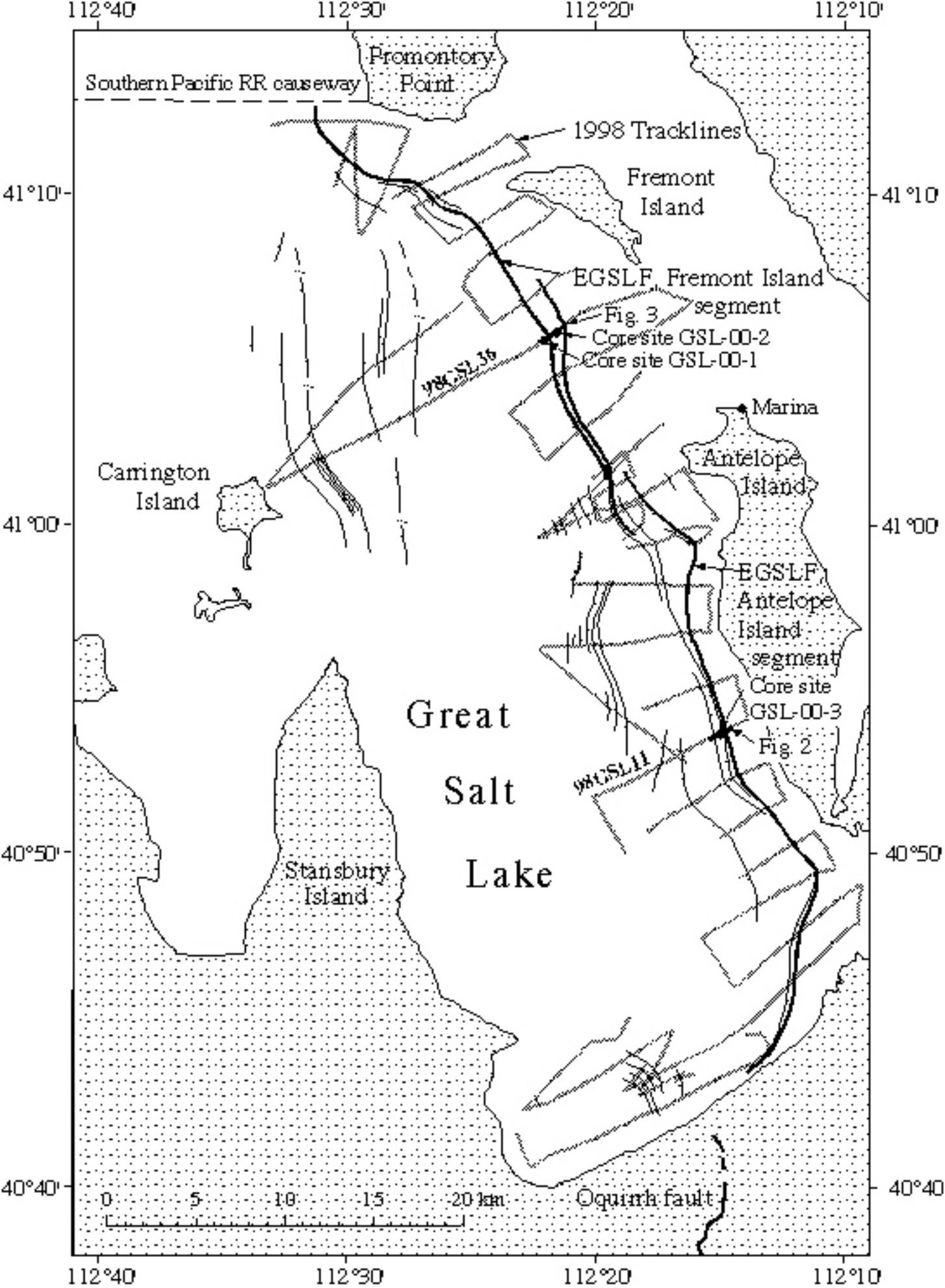

Fig. 1. Active faults in southern Great Salt Lake basin mapped from 1998 University of Utah and 1997 USGS high-resolution seismic reflection profiles (Dinter and Pechmann, 1999a, b; Colman and Kelts, 1997, GSA Abs. with Prgms., A-253); August, 2000 core sites - solid circles; East Great Salt Lake fault - heavy lines; auxiliary normal faults - light lines with hachures, dashed where inferred.

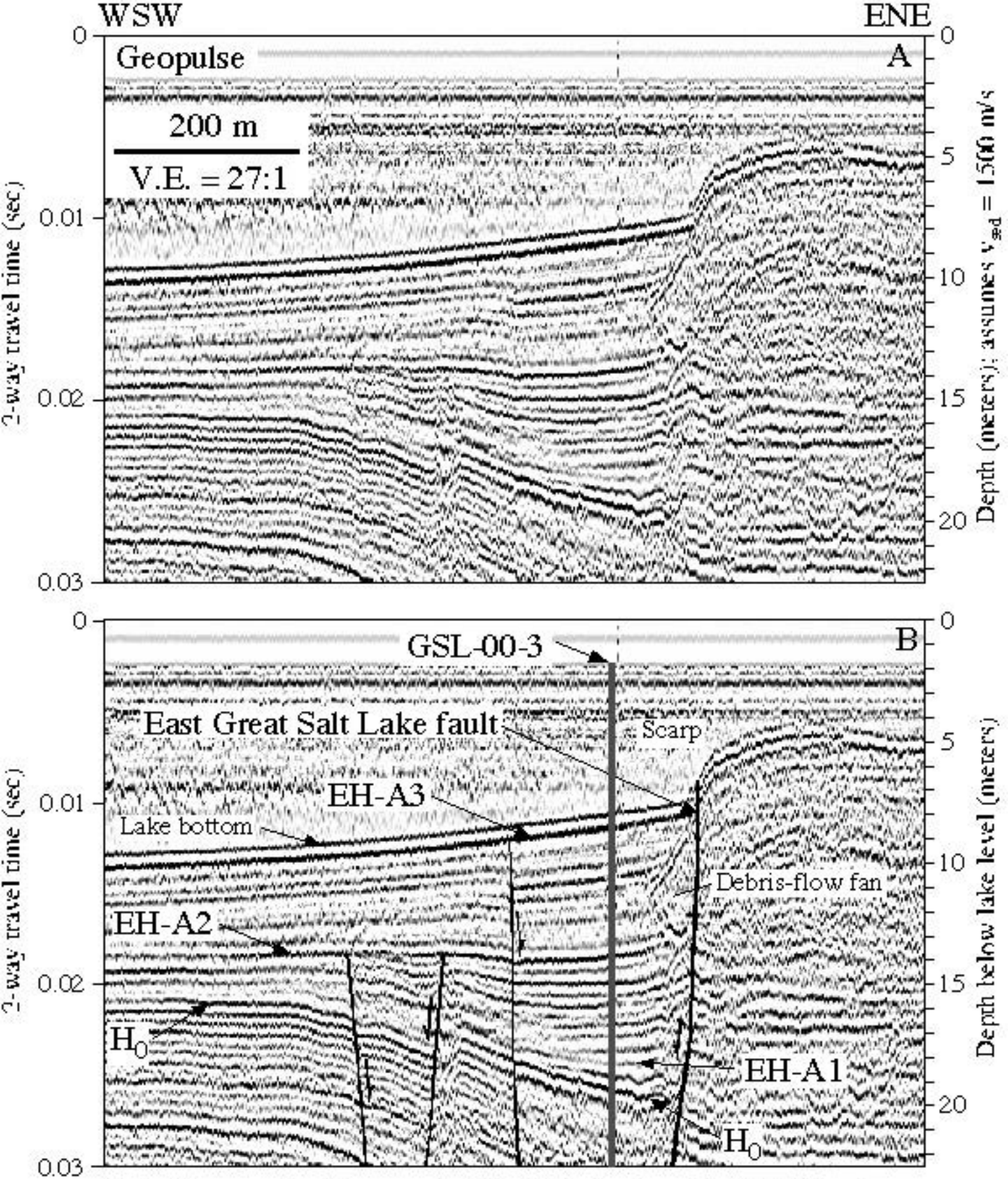

Fig. 2. Tectonostratigraphy at core site GSL-00-3 in hanging wall of EGSLF, Antelope Island segment, Geopulse Line 98GSL11 (Dinter and Pechmann, 1999a, b). V.E. = 27:1. A - Uninterpreted profile. B - Interpreted profile showing EGSLF and subsidiary normal faults, disconformity H_0 (base of modern lake deposits), Antelope-segment earthquake event horizons EH-A1 (onlap surface), EH-A2 (angular unconformity), and EH-A3 (fault termination surface). Note also middle Holocene debris-flow fan. See Fig. 1 for location.

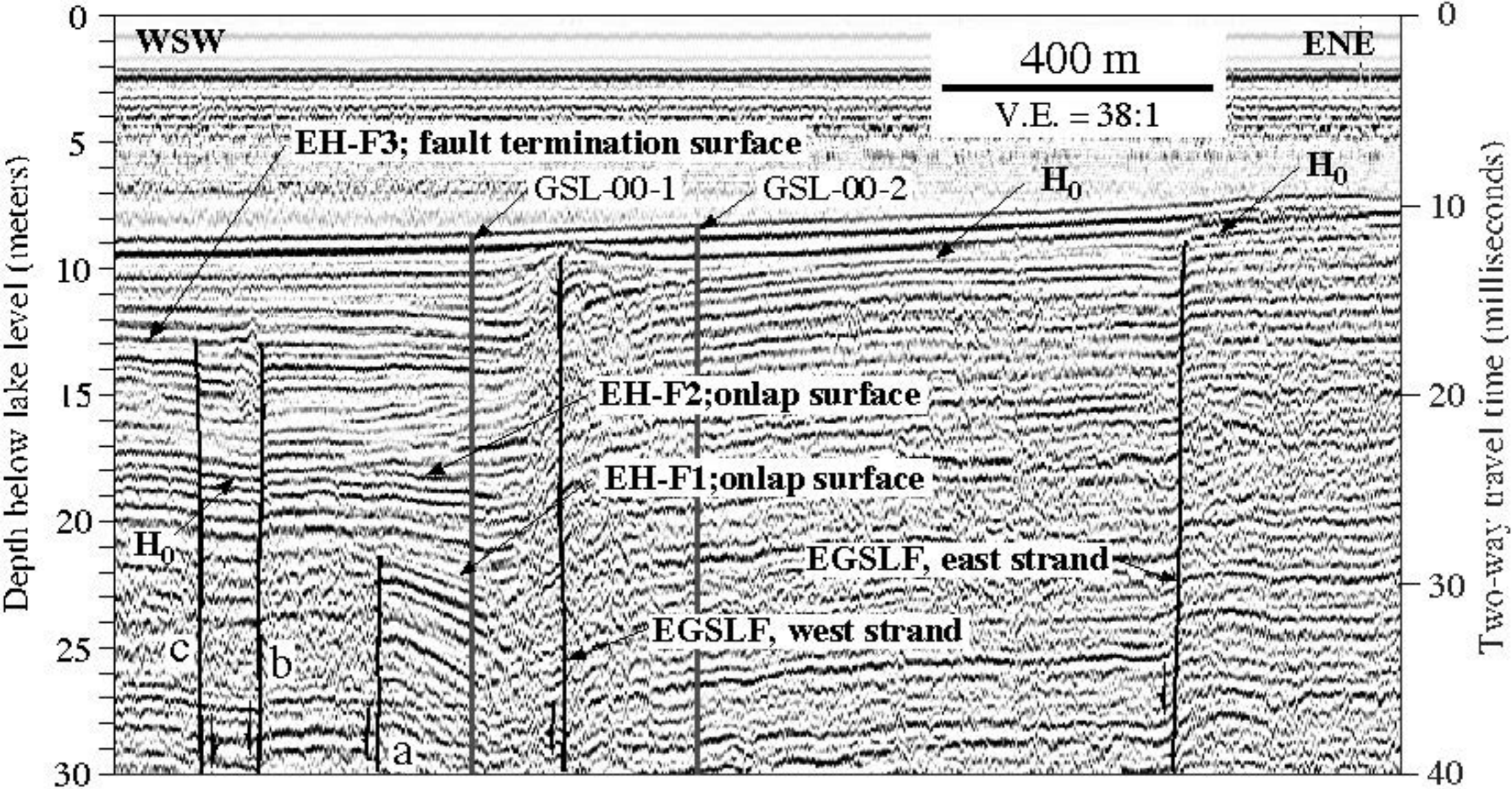

Fig. 3. Tectonostratigraphy at core sites GSL-00-1 and GSL-00-2 in hanging wall and footwall, respectively, of EGSLF west strand, Fremont Island segment, Geopulse Line 98GSL36 (Dinter and Pechmann, 1999a, b). V.E.=38:1. Note earthquake event horizons EH-F1 and EH-F2 (onlap surfaces) and EH-F3 (auxiliary fault termination surface). Auxiliary normal fault a is coseismic with Event F1; b and c are coseismic with Event F3. Disconformity H_0 is base of modern lake deposits, underlain by 12.5-m-thick halite-sapropel sequence in hanging wall. See Fig. 1 for location.