Geophysical characterization at the North Ada and East Ada sites

A 2010 Idaho Department of Water Resources report

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Summary

This report summarizes new and existing geophysical data from areas in and around Ada County, Idaho. Geophysical data from southwest Idaho can help characterize surface and subsurface geologic features that can be used in basin characterization studies. In this report, I present results from new seismic reflection data from two locations; North Ada County and East Ada County. These new data provide detailed information that includes: (1) stratigraphy of major sedimentary units in the upper few thousand feet below land surface to delineate aquifers, (2) configuration and depth of basement rocks, (3) depths and locations of volcanic units, and (4) significant fault locations and associated displacements. Additionally, I describe related industry seismic profiles and gravity/magnetic data in and around the study areas that provide additional geological insights to both North and East Ada sites.

Introduction

Geophysical data have been used for aquifer studies throughout southwest Idaho (e.g., Wood, 1994; Barrash, and Dougherty, 1997; Liberty, 1997; Liberty, 1998; Wood and Clemens, 2002). Seismic reflection methods are well suited for aquifer studies due to the acoustic properties within basin sediments and the contrast with adjacent and underlying hard rock interfaces. High resolution seismic reflection methods are often calibrated to image the upper few thousand feet below ground while oil and gas industry seismic data are often calibrated for deeper and more regional studies. Gravity and magnetic data are useful to identify and characterize the regional-scale geologic framework due to the large physical property contrast of basin sediments and hard rock. However, these methods also can address site specific targets when spatial sampling is sufficient for shallow geologic targets. Other geophysical methods including resistivity can also help characterize strata that control groundwater flow (e.g., Lindholm, 1996).

Here, I present data from a new geophysical campaign to identify and characterize geologic and hydrogeologic targets in the upper few thousand feet at two field areas in southwest Idaho. The first field site is termed the North Ada Study Area (Figure 1). This site is located near the Ada, Canyon, and Gem County line. The second field site, termed the East Ada Study Area, is located near the Ada and Elmore County line. New high-resolution seismic profiles for these sites, an analysis of existing gravity and magnetic data, and an assessment of nearby industry seismic data will help constrain geologic and hydrogeologic parameters that may control groundwater flow. In this report, I will describe the geologic framework for each site, geophysical acquisition methods and results from each site.

Geologic Setting

The western Snake River Plain (WSRP) is a 40 mile by 180 mile intracontinental rift basin that extends across southwest Idaho (e.g., Wood, 1994; Wood and Clemens, 2002). The northwest-trending basin contains Neogene and younger strata upwards of 2 miles deep. Extension began in mid-Miocene where Idaho Batholith granite was likely replaced by intrusive diabase or gabbro rocks. Columbia River and younger basalts filled the extending basin and lie upon the intrusive rocks. Neogene and younger lacustrine and fluvial sediments lie above the basement rocks, caused by paleo Lake Idaho that filled the WSRP to an elevation of approximately 3,600 feet. The lake remained until a spill point was created at Hells Canyon that eventually drained Lake Idaho into Oregon down the modern Snake River (Wood, 1994).

The North Ada site is located north of Eagle, Idaho along the northern margin of the WSRP at an elevation range from about 2,500-3000 feet (Figure 1). Here, a transgressive lacustrine sequence termed the Terteling Springs Formation lies beneath coarse-grained deposits of the Idaho Group and primary aquifer (Figure 2; Wood and Clemens, 2002). The Miocene and younger shoreline sands interfinger with lake muds and alluvial deposits. Underlying and adjacent bedrock likely consists of Cretaceous granite of the Idaho Batholith and thin Miocene basalt flows. The proximity of the North Ada site relative to the northern margin of the WSRP suggests faults may offset aquifer sands and influence groundwater flow. Groundwater flow directions are to the west/northwest toward the western limits of the WSRP and water depths range from 100 to 500 feet (e.g., Lindholm, 1996)

The East Ada site is located along the Ada and Elmore County line at an elevation range of 3,100-3,500 feet (Figure 1). Due to the higher elevations relative to peak paleolake water levels, mostly near-shore Lake Idaho lacustrine sediments are present. The area contains mostly Quaternary terrace gravels and interfingered Pleistocene basalt flows that lie above Cretaceous Idaho Batholith granitic basement. Water table depths extend to more than 300 feet below land surface in many locations and regional groundwater flow directions are to the southwest (Lindholm, 1996). The proximity of the East Ada site relative to the northern margin of the WSRP suggests faults may offset aquifer sands and influence groundwater flow. Additionally, basalt flows from the center of the WSRP and extend to the East Ada site. Water well logs suggest these northward thinning basalts do not appear along the northern margin of the site and are upwards of 100 ft thick in some wells near the Interstate 84 crossing. The extent and influence of these basalts on groundwater flow are unknown.

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Regional Geophysical Framework

The subsurface geology of the WSRP can be best characterized with a variety of geophysical methods and deep boreholes (Figures 1 and 2). Seismic reflection data suggest a fault-bounded northwest-striking graben filled with lacustrine sediments and interbedded and surface basalt flows (e.g., Wood, 1994; Liberty, 1998; Liberty et al., 2001; Wood and Clemens, 2002; Figure 1). The seismic signature of near-shore and deep water facies are unique and correlate with Lake Idaho high-stand levels confirmed from deep exploration wells (e.g., Liberty et al., 2001; Wood and Clemens, 2002). Gravity and magnetic data suggest basement rocks vary considerably across the basin with granitic rocks dominating the boundaries of the basin and massive basalts underlying the central portions of the WSRP (e.g Mabey, 1967, McCafferty et al, 1999; Wood and Clemens, 2002). Along the flanks of the WSRP near the North Ada and East Ada study areas, intermediate density and low susceptibility granitic rocks of the Idaho Batholith dominate the subsurface (Figure 2). Below the central portions of the WSRP, high-density and high-susceptibility basalts exceed 5,000 ft thickness (Figure 3).

Gravity data can be useful to identify both regional density anomalies and more local geologic features. While the unfiltered complete Bouguer gravity map shown on Figure 1 suggests the density high (massive basalt) beneath the WSRP extends regionally and to great depths, gravity data filtered to remove the regional component show upper crustal basin structures for the North Ada area (Figure 2). Aeromagnetic data tend to highlight variations in magnetic susceptibility in the near surface (Figures 1 and 2). By mathematically raising the elevation of the acquired data, upward continued magnetic images tend to highlight deeper structures.

Through the central portion of the WSRP, a N60W-striking gravity high correlates with a magnetic low. The deep Halbouty-Chevron well, located near the center of the gravity high, penetrates ~5,000 ft of (dominantly) reversely magnetized Miocene basalt below ~2,000 ft of lake sediments. To the east, the Julia Davis geothermal well penetrates ~1,500 ft of lacustrine sediments before encountering a very thin sequence of basalt overlying rhyolite and granitic rocks of the Idaho Batholith. This transition between a massive basalt basement and a dominantly granitic basement correlates with a NW-striking ~30 mgal gravity gradient along the northern portion of the WSRP. Large-offset faults are mapped along industry seismic profiles between the Halbouty-Chevron well and the Boise River (Wood, 1994; Wood and Clemens, 2002; Figure 2). These faults may provide the eastward limits of massive Miocene basalt basement rocks and may control deep groundwater flow.

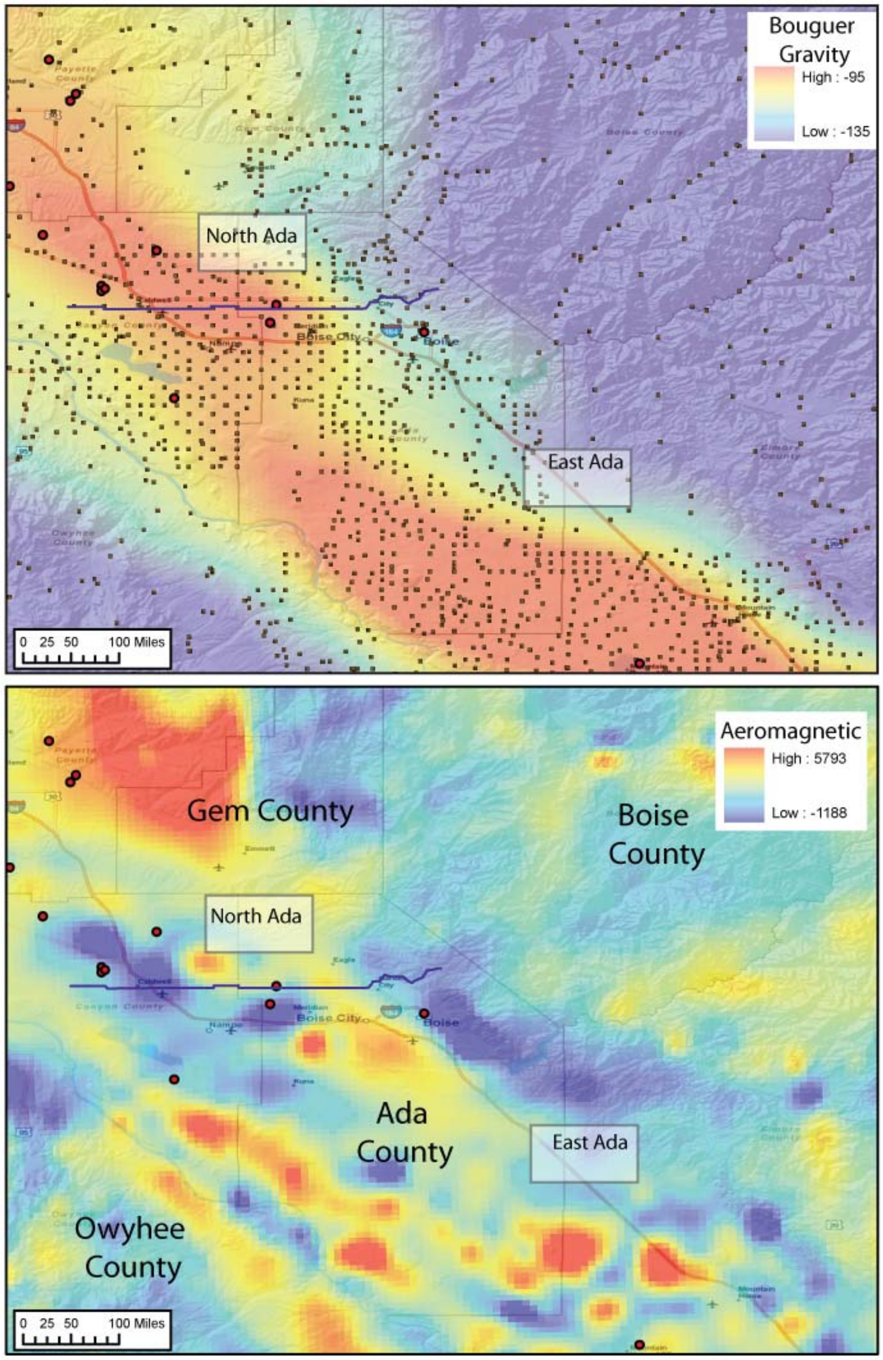


Figure 1. (top) Bouguer gravity and topographic map for the WSRP area showing high-density basalts dominate the subsurface beneath lacustrine sediments of paleo lake Idaho. Black dots represent gravity station locations. (bottom) Total field magnetic and topographic map of the study area. High magnetic values (reds) correlate with surface and subsurface high-susceptibility basalt flows whole intermediate and low susceptibility areas (blue) represent either reversely magnetized basalt flows or relatively non-magnetic rocks (e.g sediments or granitic rocks). Northwest-striking lineations dominate the WSRP, suggesting volcanic emplacement during basin formation. Blue line on each map is the seismic profile IB-2 (see Figure 2) and North Ada and East Ada study areas are shown as boxes on each figure. Red circles represent deep boreholes that extend to bedrock depths. Data from McCafferty et al., 1999.

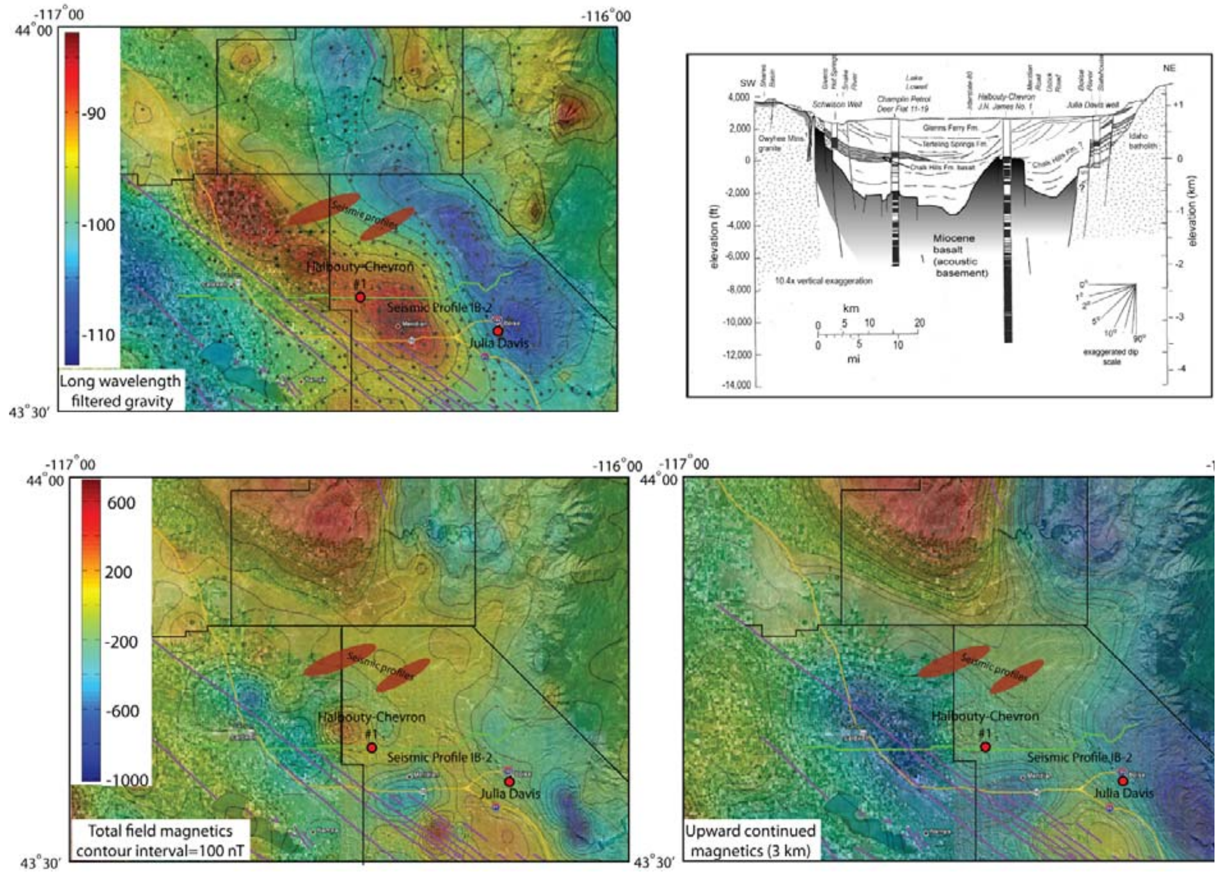


Figure 2. (top left) Filtered gravity contour map showing high-density (reds) basalt dominates the central portions of the WSRP (stations are black dots). Lower density portions (blues) are dominated by granitic rocks and overlying lake sediments. Deep boreholes (red circles), the location of industry seismic profile IB-2, newly acquired North Ada seismic profiles (rust-colored oval areas), and mapped faults (USGS database) help constrain subsurface geologic interpretations. (top right) Cross section interpretation from industry profile IB-2 (from Wood and Clemens, 2002), (bottom left) Total field magnetic map, contoured at 100 nT intervals. This map shows a 100 nT change near the North Ada site, consistent with ground-based measurements. (bottom right) Upward continued magnetic map highlighting regional magnetic features. Note the contour lines at the North Ada site parallel the gravity high. All map figures show county boundaries with superimposed aerial photo. Industry seismic profile IB-2 and location of North Ada profiles are also shown.

Ground-based magnetic measurements in the vicinity of the North Ada site show anomalies of approximately 100 nT from southwest to northeast (Wood, 2007). The aeromagnetic map shows this same northwest-striking gradient across the area, extending from north Boise, across the North Ada study area and terminating near the Canyon County/Gem County line (Figure 2). The magnetic, gravity, and seismic data from the region all suggest the lacustrine sediments associated with the northern margin of the WSRP increase in thickness from northeast to southwest. Gravity and magnetic lineations may tie to a regional fault system that has controlled sedimentation along the northern border of the WSRP.

Seismic Reflection Methods

Seismic reflection methods are commonly used in exploration for hydrocarbons, coal, geothermal energy, and in shallow applications for engineering, groundwater and environmental targets. Seismic reflection data acquisition involves a seismic source and an array of sensors or geophones (Figure 3). The seismic source can range from explosives, hammers, and vibroseis sources, all coupled to the ground surface. The seismic source is intended to propagate sound waves through the subsurface. At each seismic velocity or density contrast in the subsurface, the seismic energy is partitioned. A portion of the seismic energy is reflected back to the earth's surface while another portion of the seismic energy continues to radiate away from the seismic source. The ground displacement, as the seismic energy returns to the earth's surface, registers on a geophone (similar to a motion sensor) as a change in voltage and the analog signal that represents ground displacement is digitally recorded with a seismograph. Seismic boundaries with large velocity and/or density contrast can include the water table, bedrock surface, and a significant change in porosity or grain size within a sedimentary sequence (e.g., clay to sand).

Once seismic data are recorded, seismic processing steps include removing or attenuating coherent and random signals not related to the reflection energy, a data sort from shot gathers to common midpoint gathers, a seismic velocity analysis and correction, elevation corrections to a common datum, and stacking data at varying ray geometries to produce a section that simulates a geologic cross section (e.g., Yilmaz, 2001).

Seismic reflection data interpretation involves identification of coherent reflectors, offsets in these reflectors, and the strength of the reflected signals. Tied to borehole information, seismic velocities, and geologic and other geophysical data, a geologic interpretation is formed. It is important to note that reflecting boundaries represent a change in physical properties at a measured travel time. A tie to borehole and geologic information provide the link between seismic data and a geologic interpretation. Depth estimates from seismic velocities alone are not precise, but serve as a reasonable first-order estimate of reflector depth. To more accurately tie seismic data to accurate depth estimates, extrapolation from borehole measurements are needed.

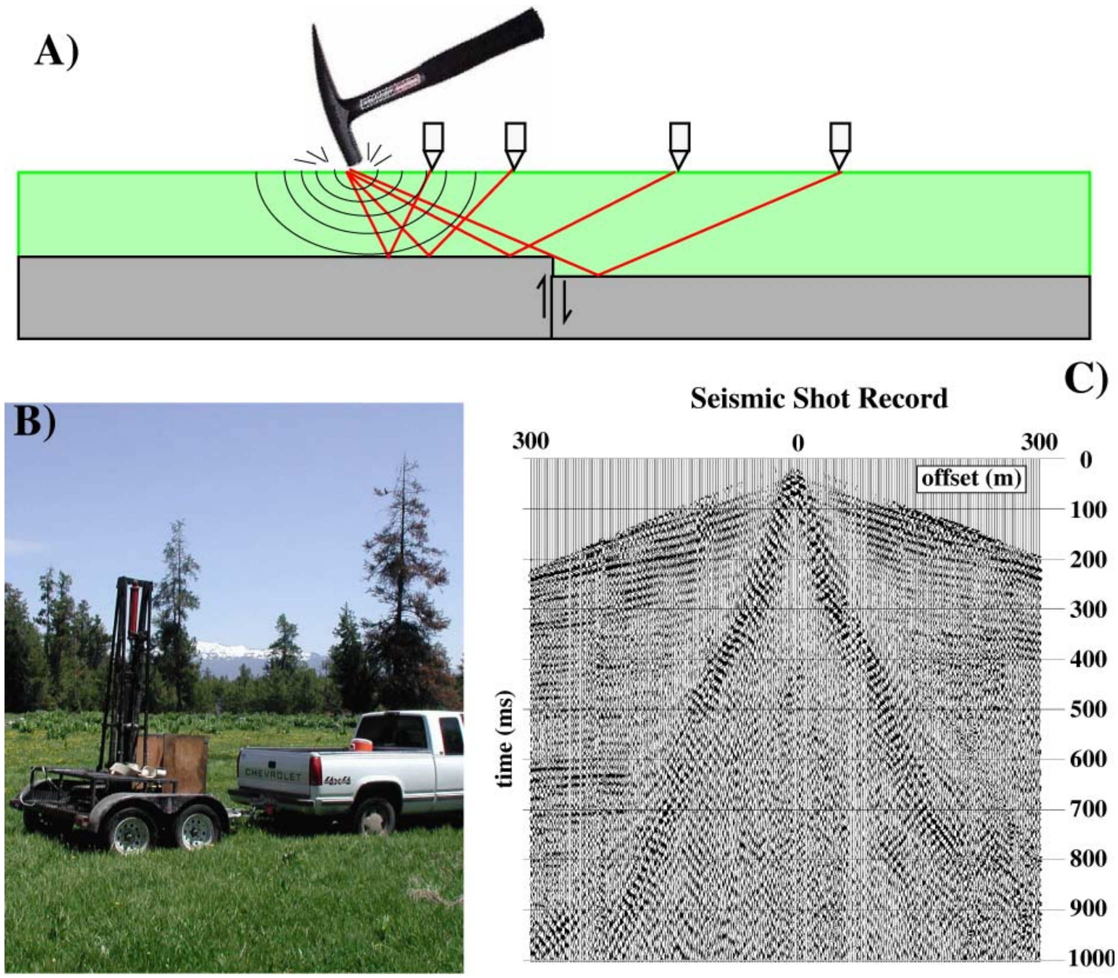


Figure 3. A) Cartoon of acoustic waves transmitting from a hammer source through a subsurface layer and returning to geophone locations at the surface. B) A Boise State University 500 lb rubber band accelerated hammer source. C) An example shot record showing reflections and other coherent and random signals. Longer travel paths appear on the down side of the fault (on A). These longer travel paths result in delayed reflector travel times (on C).

Industry seismic data

Industry seismic data from southwest Idaho were obtained throughout the 1970's through 1980's. Some of these data are presently in the public domain and can be displayed and interpreted with few restrictions (e.g., Wood, 1994; Figure 2). Other datasets are available for purchase at a cost of $2,200 per mile (2009 cost estimate) through the Seismic Data Exchange brokerage. A visit to Seismic Data Exchange (Denver, Colorado – summer, 2009) by Spencer Wood (Emeritus Boise State Professor) and the author led to the conclusion that data in the study areas at target depths were not worth the cost of purchase. Reasons include the paucity of information in the upper 1,000 ft, the high cost of purchase relative to acquiring new seismic data, and the profile locations relative to the areas of present-day interest.

North Ada County seismic reflection profiling

I acquired 4 seismic reflection profiles to characterize stratigraphy and faults in the North Ada area. New data were acquired along Chaparral Road west of Hwy 16 and along Farmers Canal and Little Gulch east of Hwy 16 (Figure 4). A final north-south profile was acquired along Lanewood Road to determine whether a proposed fault extends to the northwest. Three of the 4 seismic profiles were acquired with the Boise State 500 lb trailer-mounted accelerated weight drop source (Figure 3). The Chaparral seismic profile was acquired with a 16,000 lb vibroseis truck rented from the University of Texas NEES facility (http://nees.utexas.edu). Although both seismic sources can image the upper few thousand feet below land surface, the vibroseis truck is more capable on city streets and imaging through dry sediments. All profiles were acquired with a 16 ft source and receiver spacing and a 120-channel seismic recorder. Source offsets varied for each profile, but generally each profile was acquired off-end with offsets up to 2,000 ft. A 10 Hz geophone frequency allowed a broad-band response to image to depths up to 5,000 ft. The following sections describe new seismic results from the North Ada area.

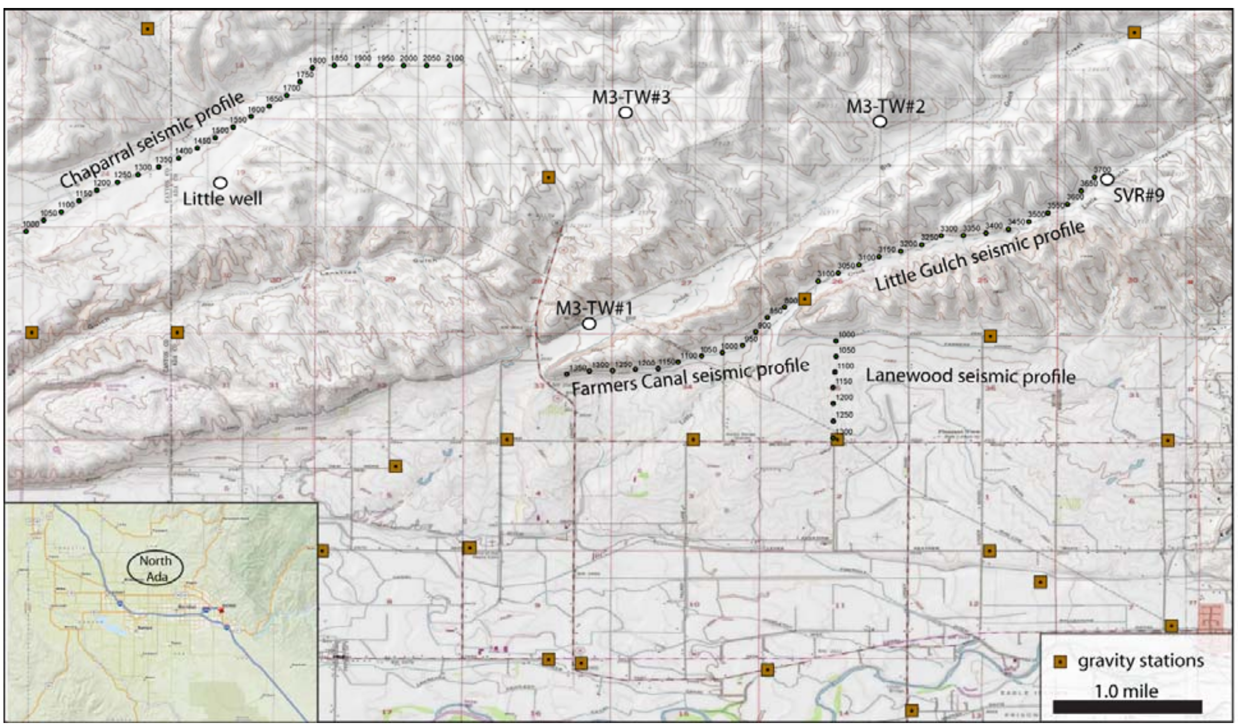


Figure 4. Location map for North Ada seismic profiles. Gravity stations appear as gold boxes, water wells are open circles (Hydrologic, 2007; 2008a; 2008b; 2008c). Inset map shows the WSRP area with North Ada study site.

Chaparral Road seismic profile

The 3.4 mile long west-east Chaparral Road seismic reflection profile is located north of Eagle, Idaho along Chaparral Road/Edna Lane in Ada and Canyon Counties (Figure 4). The vibroseis seismic profile begins at the intersection of Blessinger Road/Edna Lane along the south shoulder of the paved road. The profile terminates near Hwy 30 at the end of Chaparral Road. Elevation increases approximately 130 ft from west to east (Figure 5). The profile was acquired in Canyon County from positions 1,000-1,380 and Ada County from positions 1,380-2,070. An approximate 30 degree bend in the road is located at position 1,800, a buried pipeline crossed the road at position 1,565 and overhead powerlines, drive ways, and cross streets provided difficulties with data acquisition and introduced noise into the final stack.

The unmigrated travel time seismic section and migrated, depth-corrected and interpreted Chaparrel seismic image is presented in Figure 5. The seismic data are corrected for a 2,625 ft datum and displayed at approximately 2:1 vertical exaggeration. At approximately 0.2-0.3 s two-way travel time (twtt), a generally flat-lying reflector appears across the profile. A non-reflective zone both above and below this reflector extends to approximately 0.3-0.4 s twtt from west to east respectively while a zone of highly reflective, west-dipping reflectors extend to approximately >1.0 s twtt. Below 1.0 s, a zone of weak amplitude reflectors is present to more than 1.5 s twtt.

Given measured seismic velocities of the near-surface layers (approximately 1,400-2,500 ft/s) and water depths measured in nearby wells, I interpret the 0.2—0.3 s reflector as the water table at approximately 2,400-2,500 ft elevation across the profile. The generally continuously dipping reflectors below and the relative flat-lying water table reflector suggest no major faults cross this profile. The non-reflective zone both above the water table reflector and immediately below suggests little lateral continuity of velocity and density values, consistent with sands of the Idaho Group aquifer. Given the ~260 ft of Idaho Group sand interpreted in the M3-TV#3 well (HydroLogic, 2007), alternating sands and clay in the upper 600 ft of the Little Well (Figure 4), and onset of west-dipping reflectors below this depth, I believe the seismic image captures the sand unit as a west-thickening unit that approaches 1,000 ft depth along the western portions of the profile.

Below the interpreted boundary of the Idaho Group sand aquifer, a zone of highly reflective ~3 degree west dipping reflectors is consistent with Terteling Springs mudstone or deep water lake deposits from paleo Lake Idaho. Reflector discontinuities may indicate faults in the subsurface, however, the lack of change in reflector dip may imply these inferred faults may not be hydrologically significant or extend into the upper 1,000 ft depth. Some reflectors show a steepening of dip immediately below the Idaho Group sand unit that may be related to prograding delta deposition. At depths below ~4,000-5,000 ft, a zone of lower amplitude and/or discontinuous reflectors likely represents bedrock. Although this boundary is poorly imaged with this profile, my interpretation is consistent with the basement reflector depth on nearby industry seismic profile IB-25 that clearly image to these depths (S. Wood, personal comm.).

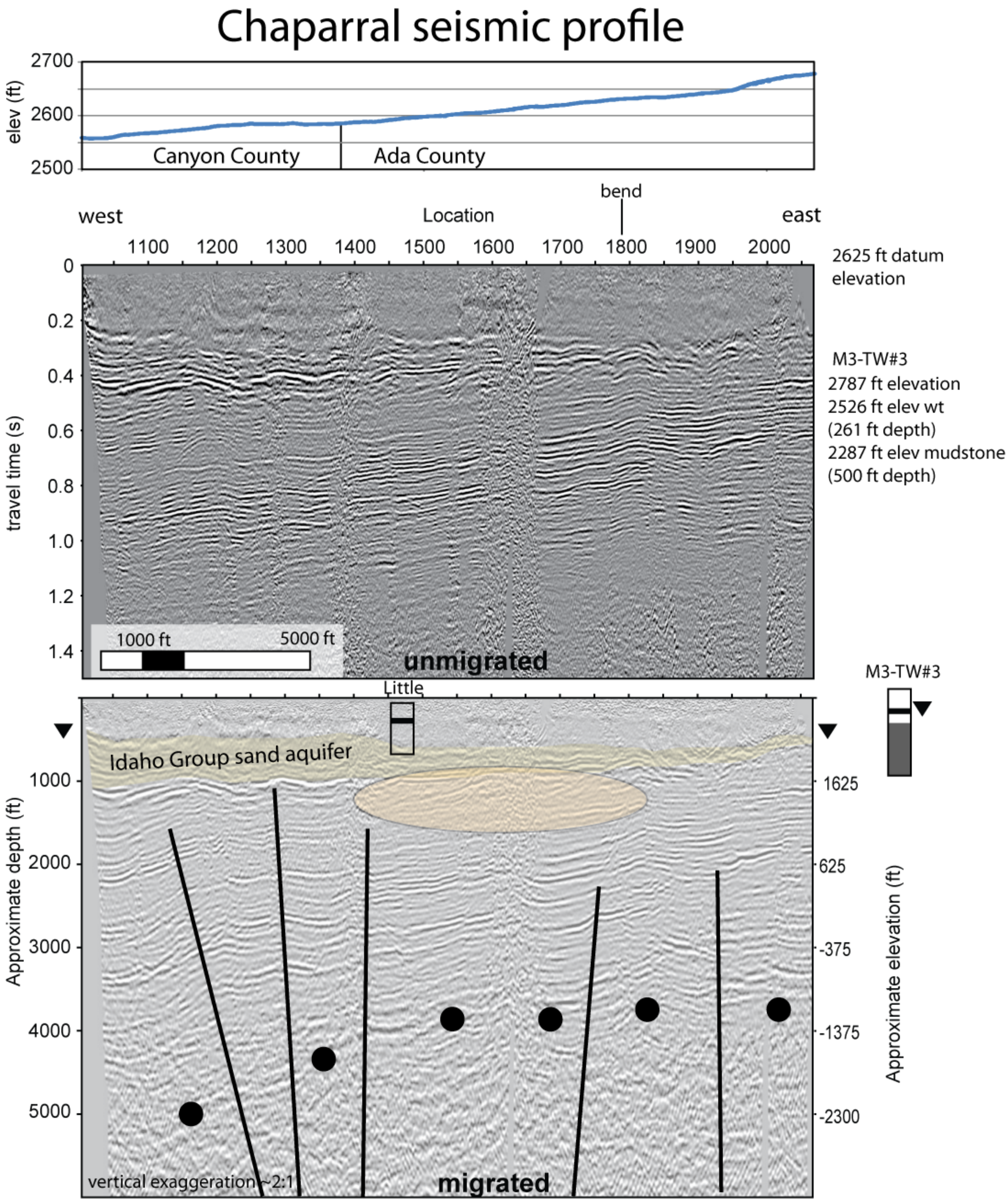


Figure 5. Elevation profile, unmigrated seismic reflection profile, and interpreted, migrated, and depth converted seismic image from Chaparral Road, Ada and Canyon Counties. Interpreted image includes inferred faults from change in reflector dip and/or offset (black lines), bedrock depth (closed circles), seismically transparent Idaho Group sand aquifer below water table (yellow), and variable dip reflectors that represent a prograding delta sequence (orange). Seismic profile and M3 TW#3 well (HydroLogic, 2007) location and station numbers are shown on Figure 4.

Little Gulch seismic profile

The 2.3 mile long west-east Little Gulch seismic reflection profile is located north of Eagle, Idaho on Bureau of Land Management (BLM) property in the foothills adjacent to private property (Figure 4). The profile begins from a private residence along the bottom of the gulch, east-northeast along a dirt road to the eastern termination of BLM property, an increase in elevation of approximately 100 ft (Figure 6). A gap of approximately 1,500 ft separates the Little Gulch seismic profile from the Farmers Canal seismic profile (described below) to the west (Figure 4). The lack of cultural noise or infrastructure provided ideal listening conditions while seismic acquisition following a period of rain provided ideal source and receiver coupling. The seismic source was the Boise State trailer-mounted seismic source. Published borehole logs for nearby M3 wells, including the adjacent M3-SVR#9 well, assist in the interpretation of the seismic profile (Hydro Logic, 2008a).

Figure 6 shows the unmigrated travel time seismic section above a migrated, depth-corrected and interpreted seismic image. The seismic images are corrected for a 2,700 ft datum and displayed at approximately 2:1 vertical exaggeration. At approximately 0.2 s two-way travel time (twtt), a generally flat-lying reflector appears across the profile. A non-reflective zone appears both above and below this reflector to approximately 0.3-0.4 s twtt from west to east respectively while a zone of highly reflective, west-dipping reflectors appear to approximately 0.8 s twtt. Below 0.8 s, a zone of weak amplitude reflectors is present to more than 1.0 s while a set of discontinuous reflectors appears to approximately 1.5 s twtt.

Given measured seismic velocities of the near-surface layers (approximately 1,400-2,500 ft/s) and water depths measured in nearby wells, I interpret the 0.2 s reflector as the water table at approximately 2,500 ft elevation across the profile. The generally flat-lying reflector shows the greatest topography near position 3,450, coincident with a change in dip of deeper reflectors. The non-reflective zone both above the water table reflector and immediately below suggests little lateral continuity of velocity and density values, consistent with the Idaho Group sand aquifer. Given the ~370 ft of Idaho Group sand interpreted in the M3-SVR#9 well (HydroLogic, 2008) and onset of west-dipping reflectors below this depth, I believe the seismic image captures the Idaho Group sand unit as a west-thickening unit that approaches 600 ft thick along the western portions of the profile.

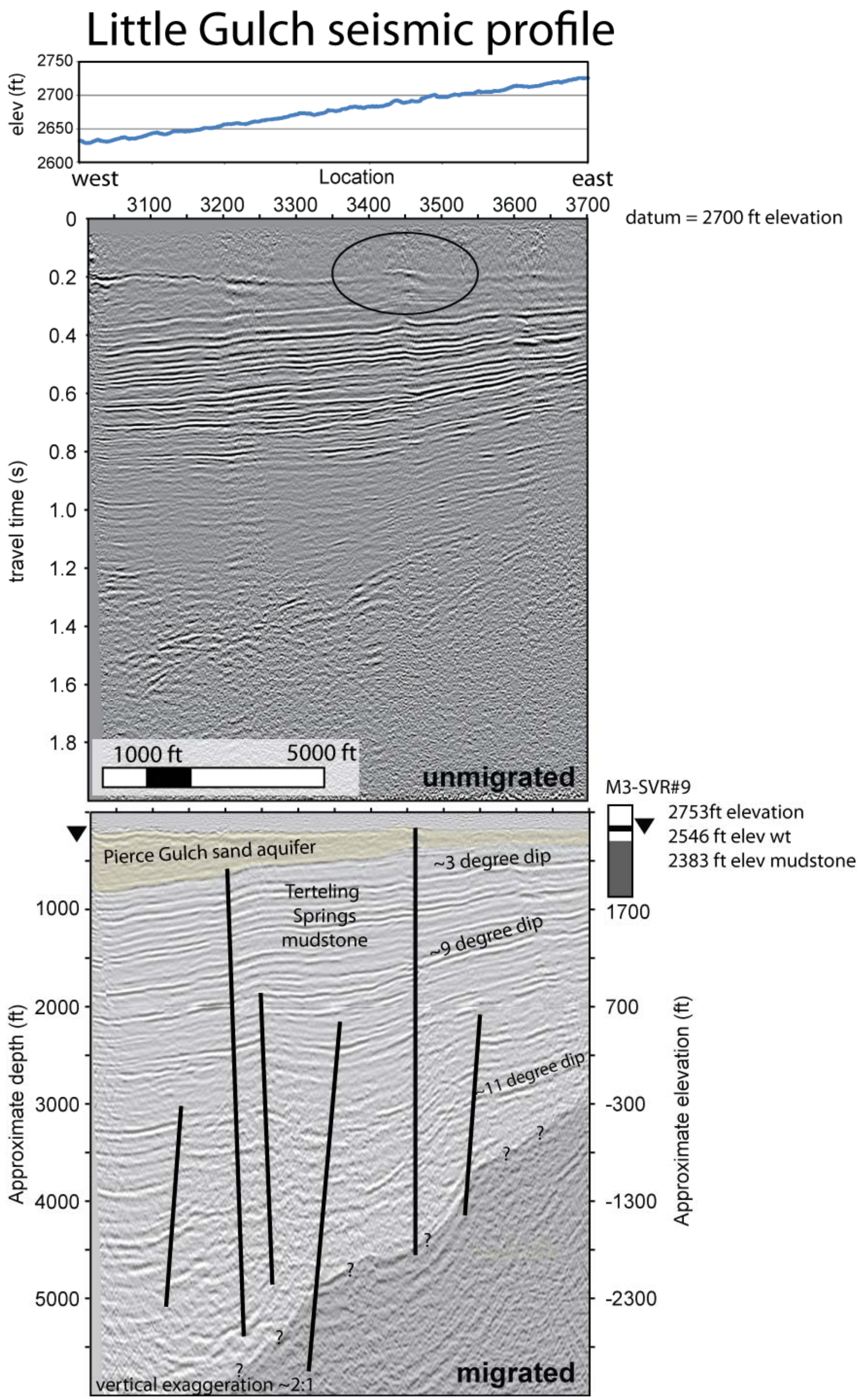


Figure 6. Elevation profile, unmigrated seismic reflection profile, and interpreted, migrated, and depth converted seismic image from Little Gulch, North Ada County. Interpreted bedrock depth (?) is inferred from diffractions on the unmigrated profile. Seismic station number locations are shown on Figure 4, water well from Hydrologic (2008b).

Below the interpreted boundary of the Idaho Group sand aquifer, a zone of highly reflective west dipping reflectors is consistent with Terteling Springs mudstone or deep water lake deposits from paleo Lake Idaho (Figure 6). Reflector dips generally increase to the east and with depth along the profile. A change in reflector dip with depth is consistent with basin subsidence with continued deposition. Abrupt changes in reflector dip, particularly noticed at positions 3,200 and 3,450 are consistent with normal faults that accommodate extension of the western Snake River Plain. The interpreted fault at position 3,450 likely extends to the near-surface, as evidenced by a water table elevation gain.

At depths below ~3,000 ft, a zone of lower amplitude reflectors likely represents additional Lake Idaho sediments that either contain fewer physical property contrasts compared to the overlying strata (e.g., a sand unit), or that the seismic source did not have adequate energy to clearly image these depths. However, the presence of discontinuous high-amplitude reflectors at greater depths is consistent with a basalt bedrock surface increasing from ~3,000 to >5,000 ft depth from east to west across the profile. I interpret the bedrock surface to dip westward approximately 20 degrees. However, given the poor imaging capabilities of the source at these depths, detailed mapping of the bedrock surface is difficult.

Farmers Canal

The 1.85 mile Farmers Canal profile was acquired along the south shoulder of the Farmers Union Canal between Hwy 16 and Little Gulch using the Boise State hammer seismic source (Figure 4). The canal road is relatively flat in elevation (Figure 7) and crosses Hartley Road at position 1,000. A bend in the canal road appears at position 960. Soft surface sediments and water pumps along the canal road added noise to the data, therefore data quality is poorer than the adjacent Little Gulch profile.

The seismic profile shows reflections to more than 1.0 second twtt, similar to observations along Chaparral and Little Gulch profiles (Figure 7). A prominent reflector between 0.1 and 0.2 s twtt overlies a dominantly west-dipping package of reflectors along the western portions of the profile and flat-lying reflectors along the eastern portions of the profile. Reflector topography along the profile may be hydrologically significant and is discussed below.

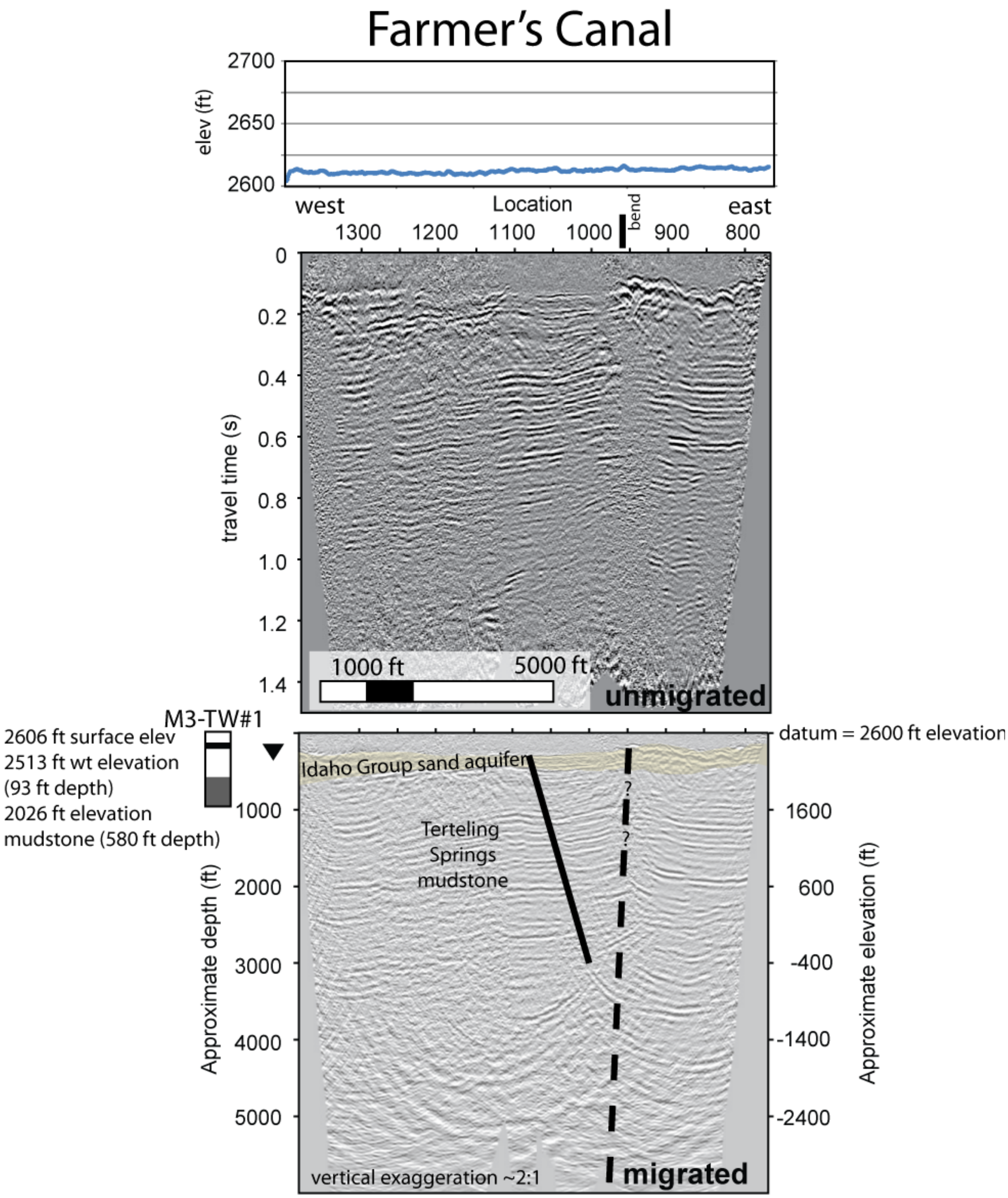


Figure 7. Elevation profile, unmigrated seismic reflection profile, and interpreted, migrated, and depth converted seismic image from the Farmer's Canal, North Ada County. Note the bend in the profile at position 960 suggests depositional dip is oblique to the profile orientation. Seismic station number locations are shown on Figure 4. Well log for M3-TW#1 from Hydrologic (2008a)

The shallowest reflector is a relatively flat-lying reflector that lies at approximately 100 ft depth that I interpret as the water table at approximately 2,500 ft elevation across the profile (Figure 7). Seismic velocities are consistent with unsaturated, unconsolidated sediments above this reflector and saturated unconsolidated sediments below. This horizon slightly shallows to the east with at least one large depth step. The largest change in water table depths appears near a bend in the seismic profile at position 960. Water table elevation change may be related to 1) the change in profile orientation and a bend in the irrigation canal or 2) a geologic fault.

Reflections below the water table are consistent with Neogene sediments within the Western Snake River Plain. I interpret the top of the west-dipping reflectors as the top of Lake Idaho Terteling Springs mustones with Idaho Group sands above this depth. The mudstone reflectors dip upwards of 6 degrees to the west along most of the profile, consistent with the depositional dip of prodelta muds of the Idaho Group sediments. The apparent reflector dip of Lake Idaho sediments changes at the bend in the seismic profile at position 960. This is consistent with either a depositional dip oblique to the seismic profile orientation or a fault. Although this pattern of reflector dips is also consistent with geologic faulting, the coincidental location of changes in reflector dip with profile orientation does not necessitate geologic structure. I interpret a fault that surfaces near position 1100 where reflector offsets separate differing reflector dips. These offsets extend into the Idaho Group sands, but it is difficult to determine whether the sand unit is offset. Reflections below ~1.0 s twtt or > 4,000 ft are difficult to interpret on this section. Given the bedrock depth along the southwest limits of the Little Gulch seismic profile, bedrock depths may exceed imaging capabilities along the Farmers Canal seismic profile.

Lanewood seismic profile

The 1.0 mile long north-south Lanewood seismic reflection profile is located north of Eagle, Idaho on a private property farm field and gravel road north of Beacon Light Road on Lanewood Drive (Figure 4). The profile begins at the Farmers Canal immediately south of West Homer Road, extends south across a farm field and gravel road to terminate at West Beacon Light Road, a decrease in elevation of approximately 45 ft (Figure 8). The lack of cultural noise or infrastructure provided ideal listening conditions while seismic acquisition following a period of rain and frozen ground provided ideal source and receiver coupling.

Figure 8 shows the unmigrated travel time seismic section for the Lanewood section. The seismic image is corrected for a 2,600 ft datum and displayed at approximately 2:1 vertical exaggeration. At approximately 0.1 s two-way travel time (twtt), a generally flat-lying reflector appears across the profile that I identify as the water table at approximately 75 ft depth. A zone of high reflectivity appears immediately below the water table reflector to approximately 0.8 s twtt, suggesting the Idaho Group sand aquifer is thin at this location and mudstones of the Lake Idaho unit appear within the upper 100-200 ft depth. Below 0.8 s, a zone of weak amplitude south-dipping reflectors is present to more than 1.0 s possibly related to bedrock. However, the weak signal returns places high uncertainties as to the bedrock character. Given the dominantly flat-lying reflection character within the Lake Idaho sediment, I do not identify any geologic faults that offset bedrock and overlying strata. The inferred fault that Wood (2007) projects (based on a 100-200 nT magnetic anomaly to the northwest) or the possible fault identified on the Farmers Canal profile (Figure 7) does not appear to cross this profile suggests 1) the fault does not extend to the southeast across the Lanewood Road, 2) the fault offsets deep bedrock, but does not extend into the near surface (explains the magnetic anomaly), or 3) the fault is farther south than this profile was acquired. A planned addition to this seismic profile should be complete during the Fall, 2010.

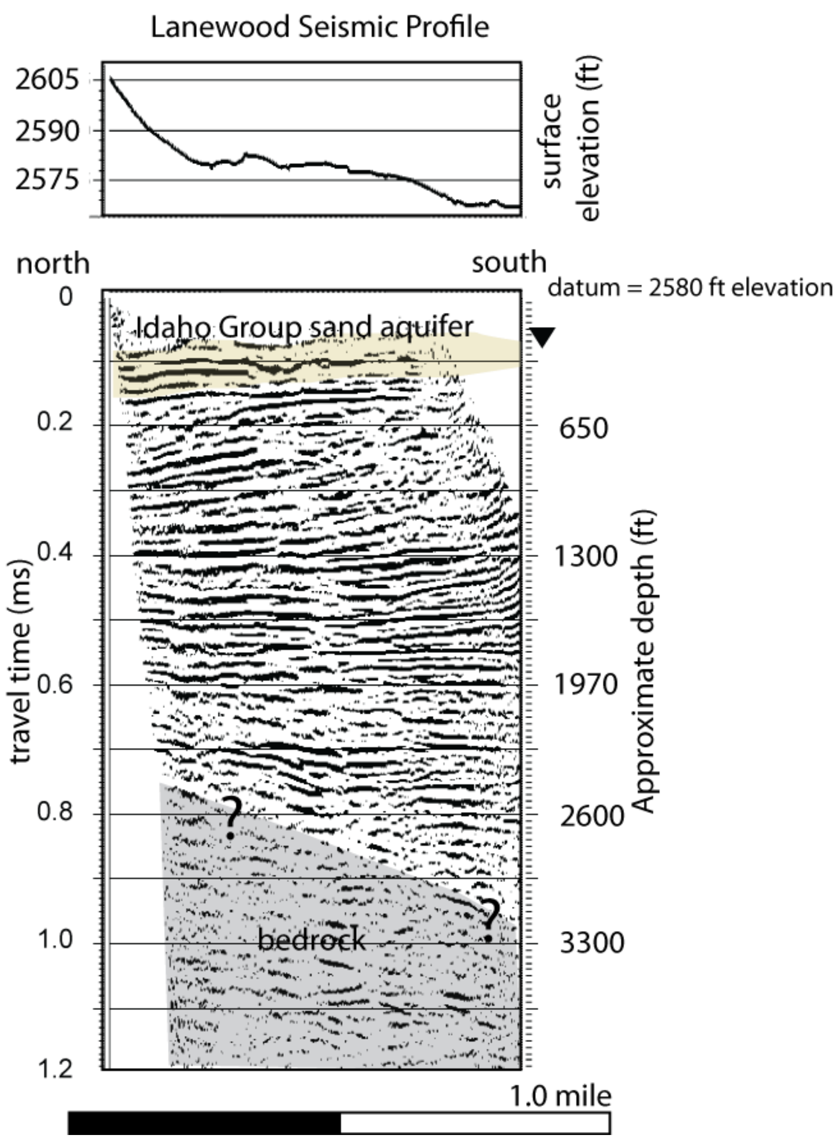


Figure 8. Lanewood seismic profile, north Ada County. The seismic image shows mostly flat-lying reflectors with no indication of faulting. Moderate dips within the Lake Idaho sediments are likely depositional in origin. Seismic station number locations are shown on Figure 4.

East Ada County/West Elmore County geophysics

Three seismic profiles were acquired in easternmost Ada County and westernmost Elmore County (Figure 1). Additionally, a grid of magnetic profiles was acquired in the area near the Stagestop Plaza. This portion of the report describes these data in detail.

Magnetics of the Mayfield-Stagestop area

During the summer, 2009, Boise State University geophysics students (Andrew Nies, Jason Compton and Kyle Lindsay) measured the total magnetic field along an approximate 2 sq mile area in eastern Ada County near the Mayfield exit and Stagestop rest area (Figures 1 and 9). The survey area was bisected by the South Orchard Access Road and constrained to the north by the Old Hwy 30 access road with south-north parallel lines acquired across much of the area. Interstate 84 extends southeast through the survey area, forcing the students to divide the area in multiple surveys. The Stagestop seismic profile also crossed the central portions of this survey area. The purpose of the survey was to identify geologic boundaries that may have a hydrogeologic significance in an area with highly variable water levels, specifically the presence of buried basalt layers that may provide fluid flow barriers or conduits.

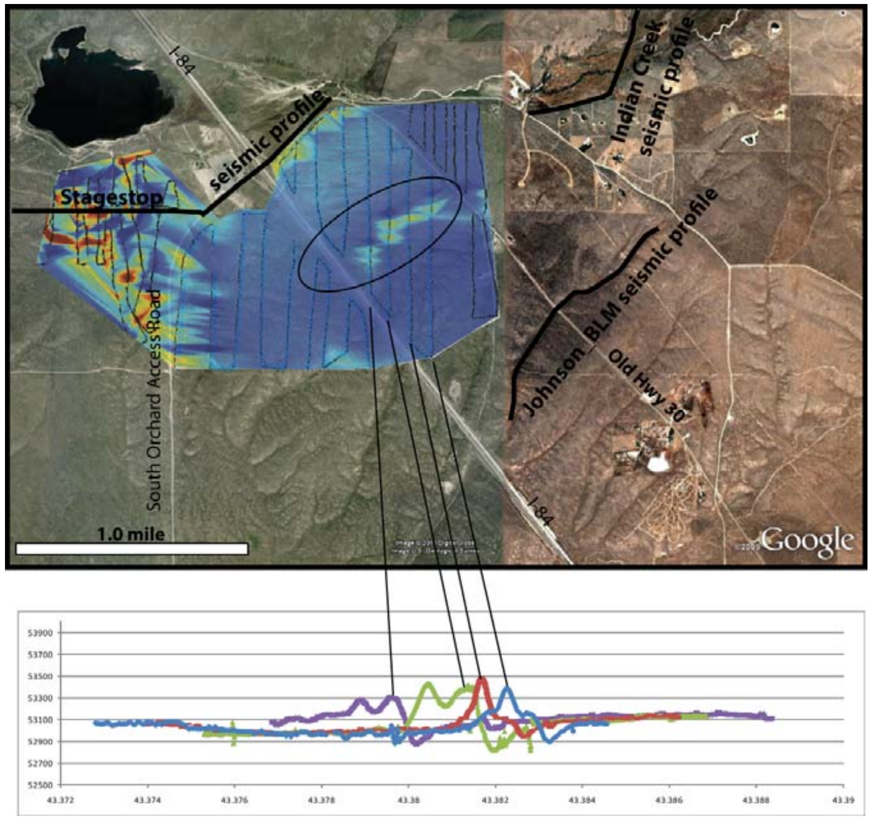


Figure 9. Magnetic survey area in East Ada county adjacent to the Mayfield Stagestop. Total magnetic field is high along the western and northern limits of the survey, related either to near-surface basalt flows or cultural features that contain either a magnetic or electrical signal. Along the 4 eastern profiles, I have circled a lineation that likely is affiliated with a buried basalt flow.

Background total field measurements were acquired at a basestation each day of acquisition with diurnal variations in the magnetic field measuring 10’s of nT, with a median background level of approximately 53,300 nT. Total field measurements along the areas west of South Orchard Road were greater than background levels and greater than measurements east of this road, indicative of high susceptibility rocks west of South Orchard Road in the near surface (Figure 9). This observation is consistent with basalt outcrops mapped immediately north of the survey area where South Orchard Access Road intersects Old Hwy 30 and also consistent with water well logs from the Stagestop property where thin basalt interbeds were logged (IDWR water well database).

In addition to the high total magnetic field along the west survey area, I observe a southwest-striking dipole that crosses the eastern portions of the survey, but does not cross the Interstate-84 (circled on Figure 9). Total field value changes of approximately 500 nT on 4 parallel profiles suggest a high susceptibility magnetic body within the upper hundred ft below land surface. I interpret this lineation as a southwest-striking buried basalt flow that terminates at or near I-84. This anomaly does not extend to the northeast or southwest and is best modeled as multiple thin flows buried at depth or a single basalt flow unit with a complex geometry.

Indian Creek seismic profile

The 4.0 mile long northeast-southwest Indian Creek Road seismic reflection profile is located along Indian Creek Road between Mayfield and Elmore/Ada County boundary in westernmost Elmore County (Figure 10). The profile begins from the intersection of the foothills access road near Mayfield along the north shoulder of the gravel road and was acquired with the NEES vibroseis truck. The profile terminates at the Ada County line (Figure 11), an increase in elevation of approximately 250 ft. Basalt outcrops appear immediately north of the profile and granitic bedrock appears approximately 1 mile to the north of the northern start of the profile.

Figure 12 shows the unmigrated travel time seismic section above a migrated, depth-corrected and interpreted seismic image. The seismic images are corrected for a 3,500 ft datum and displayed at approximately 2:1 vertical exaggeration. The seismic results from the East Ada profiles show a considerably different character compared to the North Ada profiles and all require additional processing to deal with these complexities.

The unmigrated Indian Creek seismic profile shows laterally discontinuous reflections that relate to large near-surface velocity contrasts. Zones of near-surface high velocities are best explained by shallow basalt flows. Two areas where these zones appear are at positions 1,300 and 2,050, where I interpret basalt beneath the profile that laterally extends for more than 1,000 ft. The water table reflector is present in places but additional processing is needed to confidently interpret this reflector depth. Deeper in the seismic profile, a southwest-dipping reflector extends from approximately 1,000 ft depth to more than 5,000 ft depth at the Ada County line. The bedrock reflector is clearly imaged along the northern portions of the profile, with diminishing quality to the southwest. The absence of large-offset bedrock offsets suggests no significant faults cross the Indian Creek profile. The absence of continuous reflections between the near surface and bedrock suggests deep water paleo Lake Idaho sediments are limited in this area. This is consistent with lithologies identified in water well logs along Indian Creek Road.

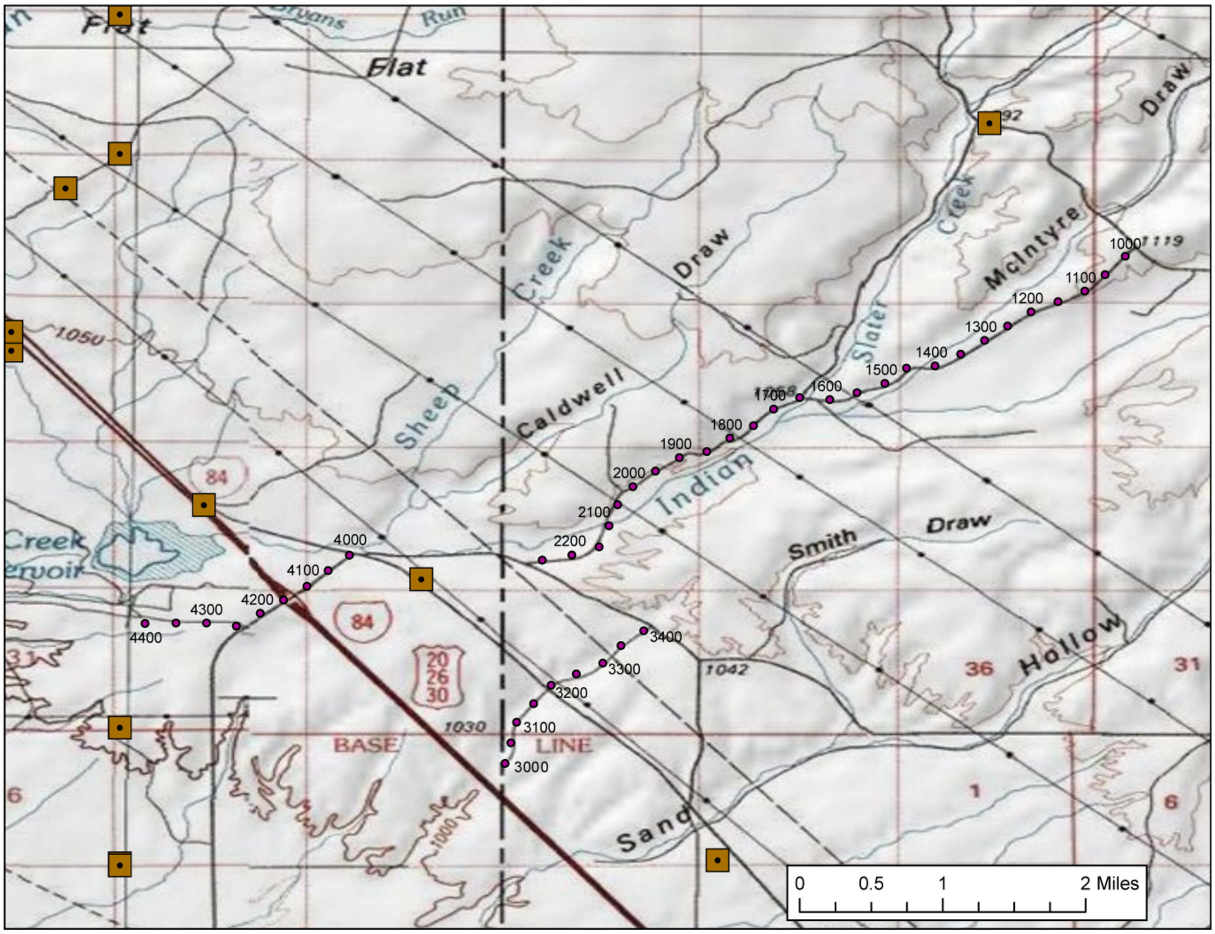


Figure 10. East Ada map showing seismic positions for the 3 seismic profiles- Indian Creek, Johnson-BLM, and Stagestop seismic profiles. Dashed line represents the Ada/Elmore County line. Orange squares represent gravity stations for the area. New gravity stations are planned by a new USGS campaign for Fall, 2010 that may provide additional geophysical constraints to subsurface geology.

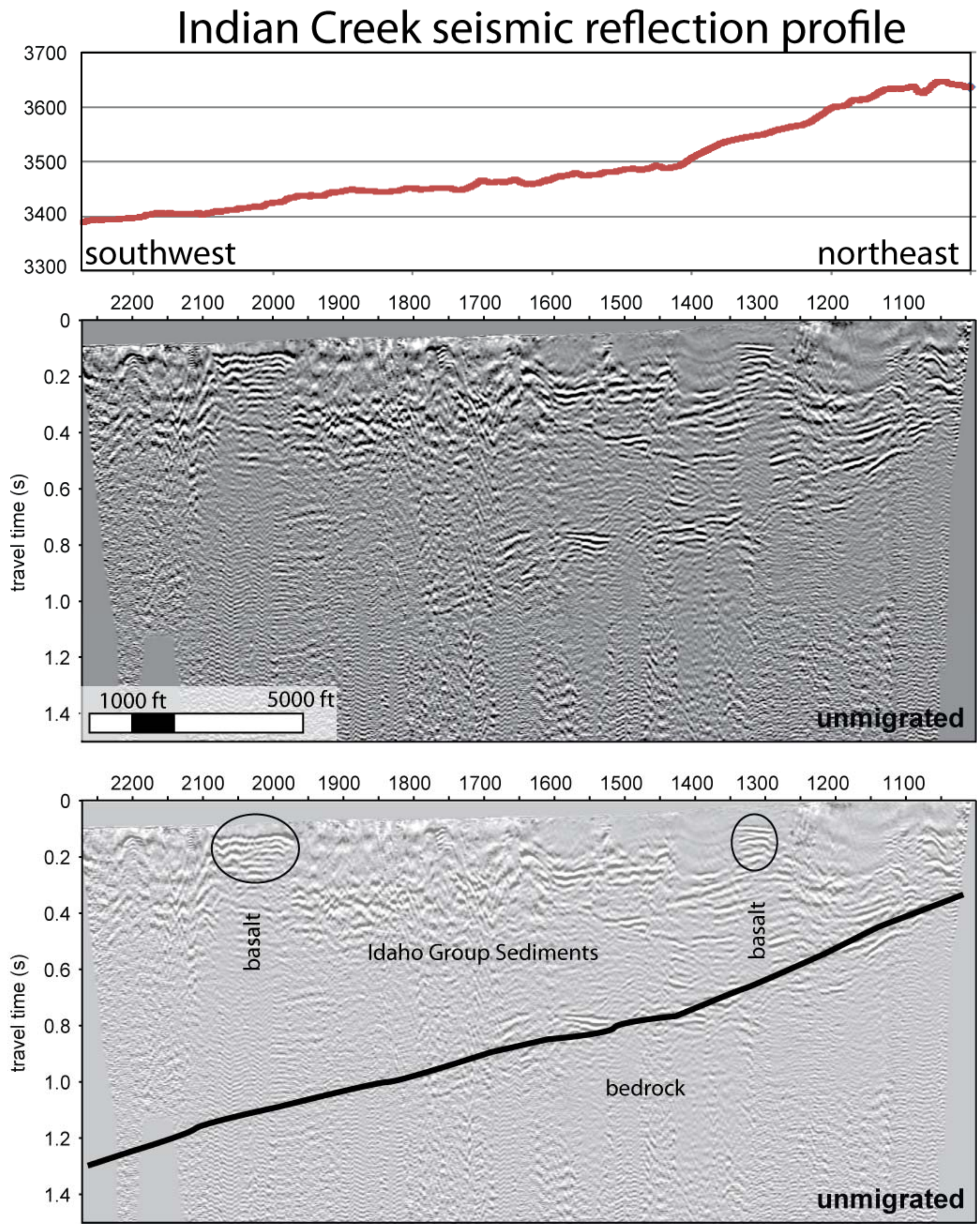


Figure 11. Elevation profile and seismic reflection section for the Indian Creek profile, East Ada County. (top) uninterpreted depth converted, unmigrated stack; (bottom) interpreted depth converted migrated stack. Seismic station number locations are shown on Figure 10.

Johnson-BLM seismic profile

The 1.3 mile south-north vibroseis Johnson-BLM seismic profile is located north of Interstate-84 in Elmore County (Figure 10) along private property (Johnson) and BLM property. The profile begins north of Interstate-84 along the southern termination of a dirt road. The road crosses old Hwy 30 near position 3,200. Total elevation gain is approximately 80 ft from south to north with the data processed at a 3350 ft datum (Figure 12). Large power lines extended overhead from positions 3,050-3,200, but the remainder of the profile contained little cultural noise or interference. A large vertical velocity gradient made it difficult to display all information clearly on one figure, so I present an image that represents the shallow water table reflector and an image that represents deeper structures.

The Johnson-BLM seismic profile shows a dominantly south-dipping package of discontinuous reflectors across much of the profile (Figure 12). The shallowest reflector at 0.3-0.4 s twtt is flat-lying across much of the profile and dips to the south between stations 3000-3150 (Figure 12 right). The deeper reflectors are south dipping approximately 10 degrees along the northern portion of the profile and dip less than 5 degrees along the southern portion of the profile.

I interpret the shallow reflector as the water table, consistent with seismic stacking velocities of 2,000-3,200 ft/s. The change in water table dip at position 3,150 corresponds with a discontinuity and change in reflector dip below that may indicate a fault. Given the relatively constant seismic stacking velocities above the water table, I do not interpret large lateral variations in geologic conditions in the upper 300-400 ft depth. However, given the presence of subsurface basalt flows mapped with magnetic profiling and nearby water well logs, the change in reflector character may reflect a change in subsurface lithologies below the water table.

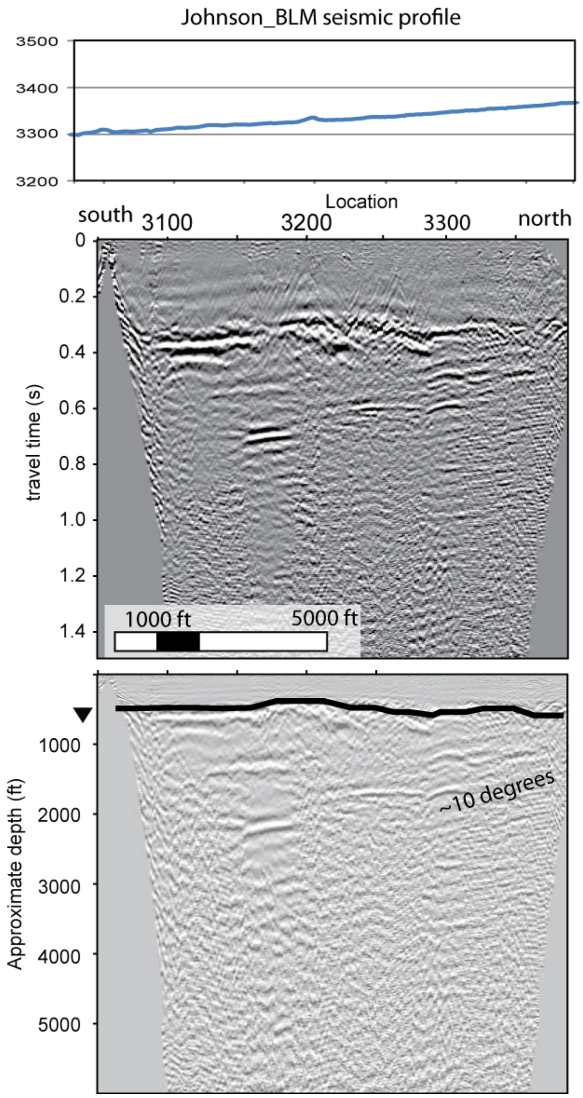
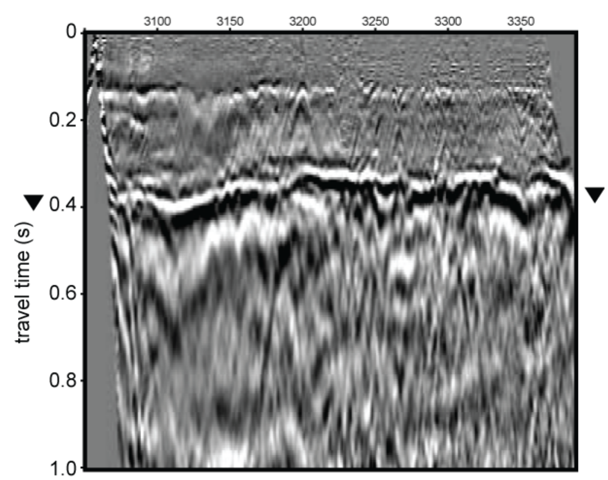


Figure 12 . (left) Elevation profile, unmigrated seismic reflection profile, and interpreted, migrated, and depth converted seismic image for the Johnson/BLM profile, Elmore County (Figure10). Note that a change in water table topography also matches offset dipping reflectors below. (below) Seismic profile processed to highlight the water table reflector. Note the flat-lying water table reflector along the northern portions of the profile and south-dipping water table reflector along the southern portion of the profile. Seismic station number locations are shown on Figure 10.



Stagestop seismic profile

The 1.5 mile northeast to southwest Stagestop seismic profile was acquired with a 12,000 lb vibroseis truck and begins at the South Orchard Road/Old Hwy 30 intersection, East Ada County (Figure 10). The profile crosses Interstate 84 at position 4,140 and extends west along a dirt road immediately south of the Stagestop Plaza at position 4,250. The profile has an elevation change of approximately 50 ft from the Interstate 84 crossing to the southwest line termination (Figure 13). The seismic profile was processed to a 3,350 ft datum.

The unmigrated travel time seismic image shows a strong south dipping reflector that ranges from 0.3 to 0.5 s twtt between positions 4,000-4,250 (Figure 13). At the bend in the seismic section (4250-4430), this reflector is near flat lying to east-dipping. Discontinuous, strong amplitude reflectors appear west of the profile bend (4250) that are not present along the north-south profile section. Seismic stacking velocities in the upper 0.4 s range from 1,500-

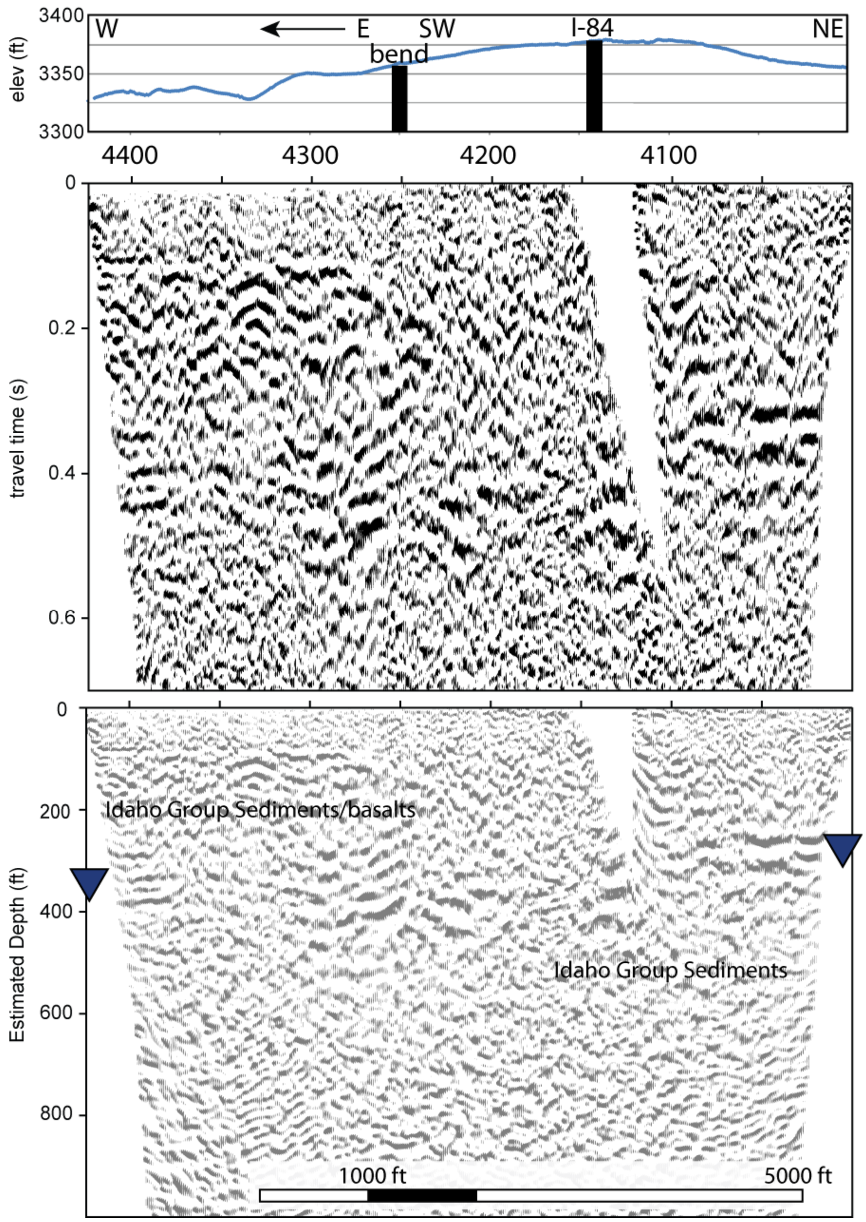


Figure 13. Elevation profile, unmigrated seismic reflection profile, and interpreted, migrated, and depth converted seismic image for the Stagestop profile, East Ada County. Note the bend in the profile at position 4250 and the gap in near-surface coverage as the profile crosses Interstate 84. A significant change in seismic character west of the profile bend correlates with interpreted near-surface basalt flows. The south-dipping water table reflector is estimated at depths between 300-400 ft. Seismic station number locations are shown on Figure 10.

2,500 ft/s along the northern portions of this profile while seismic velocities west of South Orchard Road (position 4250) are 2,500-5,000 ft/s. These slow velocities are consistent with unsaturated sediments above the south-dipping water table reflector at 300-400 ft depth across the section. The faster velocities and discontinuous reflectors that appear west of South Orchard Road are consistent with basalt interbeds in the upper few hundred feet, consistent with lithologies observed in the Stagestop Plaza water wells and also consistent with ground-based magnetic profiling (Figure 9). Reflections below the water table are poorly imaged on this profile, in part due to cultural noise and poor coupling of the sensors and vibroseis truck.

Conclusions

This report summarizes new and existing geophysical data from two areas in and around Ada County, Idaho. Seismic and well log data from the North Ada study site suggest dominantly southwest-dipping Idaho Group sediments fill the northern margin of the western Snake River Plain. Bedrock offsets correlate with gravity and magnetic lineations where, in places, normal faults bisect sedimentary units. Sands of the Idaho Group appear as zones of low amplitude reflections and extend to depths of 1,000 ft. Reflections from deep water Idaho Group sediments extend to more than 5,000 ft depth along the North Ada profiles. Seismic data from East Ada profiles suggest Idaho Group sands dominate the subsurface, increasing in thickness to the south. Increased depths to water table correlate with increasing basin depth. Buried basalts may also locally control groundwater flow,

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