Southern Grande Ronde Valley Seismic Project - Phase II: Reflection Seismic Results

Report prepared for the Oregon Department of Geology and Mineral Industries

Lee M. Liberty and Warren Barrash
Center for Geophysical Investigation of the Shallow Subsurface (CGISS)
Boise State University
Boise, Idaho 83725

DRAFT

Technical Report BSU CGISS 98-05
16 December 1998

Southern Grande Ronde Valley Seismic Project - Phase II: Reflection Seismic Results

Lee M. Liberty and Warren Barrash
Center for Geophysical Investigation of the Shallow Subsurface (CGISS)
Boise State University
Boise, Idaho 83725

1.0 Abstract

From July 15-21, 1998, Center for Geophysical Investigation of the Shallow Subsurface (CGISS) acquired a 6.7 km long east-west seismic reflection transect in the Grande Ronde Valley, north of Union, Oregon. We acquired the data with a trailer-mounted surface seismic source along Woodruff Lane and in adjacent farm fields to determine sedimentary basin structure and stratigraphy along 3 separate profiles. A well along the transect shows interbedded gravel and clay units to a depth of 140 m (460 ft) and interbedded basalt, clay, and gravel units from 140-220 m (460-720 ft) depth along Profile 1 at CMP 4400. In this region, we observe a strong correlation between lithologic changes and seismic reflections. The seismic results suggest that the basin deepens to the west along the transect, with an average apparent dip of approximately 2 degrees along the entire transect, but local apparent dips of up to 10 degrees along Profile 3. Fault locations and offset orientations also strongly correlate with mapped faults in the adjacent hills.

2.0 Introduction

The Grande Ronde Valley, located in northeastern Oregon (Figure 1), is the site of a basinwide study by the Oregon Department of Geology and Mineral Industries. The primary purpose of the work reported here is to locate and characterize faults in the volcanic units below the sedimentary basin fill which may be conduits for groundwater circulation into the basin from below, and to determine if geologic strata in the sedimentary section correlate regionally. This study is being conducted by the Center for Geophysical Investigation of the Shallow Subsurface (CGISS) at Boise State University as part of the basin-wide effort to decrease the dependence on surface water in the southern portion of the Grande Ronde Valley. In particular, we conducted a seismic reflection program with a tie to local well logs to best characterize changes in lithology, identify basin structures, and locate faults.

We initially acquired seismic data at two test sites in the southern Grande Ronde Valley, north of Union, Oregon. In addition to analyzing regional gravity and magnetic profiles (AMAX Exploration, Inc., 1975) and local well logs (Van Tassell, written

Grande Ronde Valley

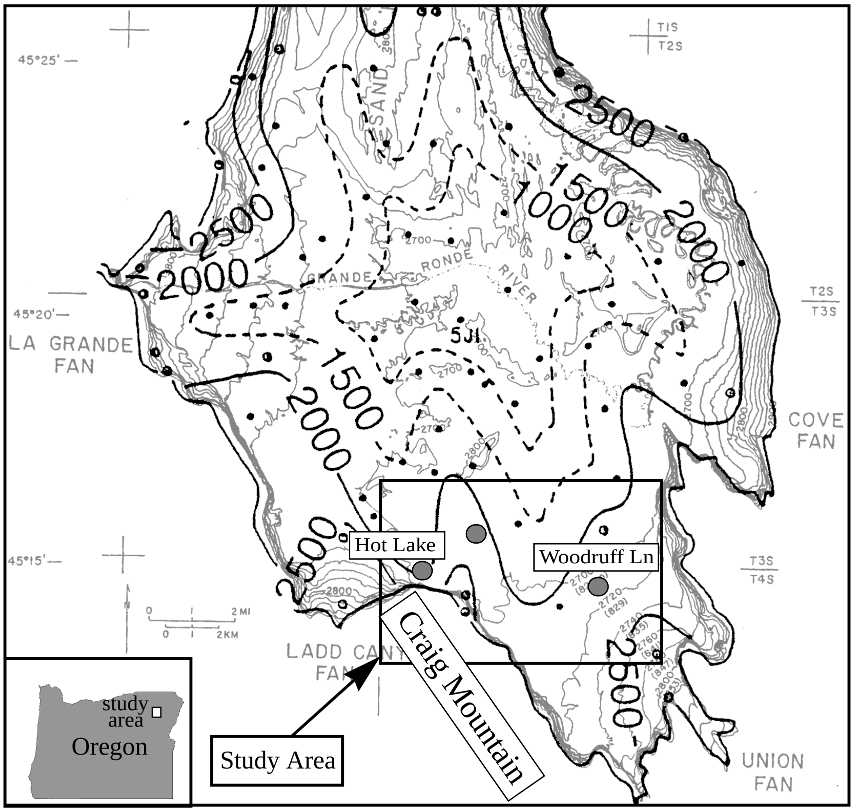

FIGURE 1. Location map for the Grande Ronde Valley in northeast Oregon. The map shows surface elevation (in ft) in light contours, bedrock elevation (in ft) in bold contours and general locations of several wells discussed in the paper. Note the major basin depocenter north of the study area. (Individual maps from J. Van Tassell)

comm.), these seismic tests served as the basis for designing the seismic reflection transect across the valley. From the initial report (Liberty et al., 1998), we determined that the depth to the upper basalt contact should be less than 500 m. Unfortunately, a continuous profile across the valley could not be acquired due to land access issues, but coverage is complete for one profile that is greater than 5 km long (Figure 2).

3.0 Setting

Figure 1 shows the location of the study area in southern Grande Ronde Valley with surface topography and bedrock (upper basalt contact) elevation. The bedrock elevation was derived from regional well logs, but only a few wells penetrate basalt in the southern portion of the valley. Lithologic logs from four selected wells in the region (Figure 2) show that bedrock topography and intrabasin stratigraphy are complex with rapid lateral changes in fine- and coarse-grained fluvial deposits, and position, thickness and number of lava flows. Bedrock topography appears to deepen basinward from the east and west range fronts (deepest near well #2, see Figures 1 and 2). The gravity and magnetic signatures (Figure 3) also suggest that the bedrock topography varies across the valley, with local bedrock lows south of Woodruff Lane near Godley Road (thus explaining the

Grande Ronde Valley Seismic Test Site

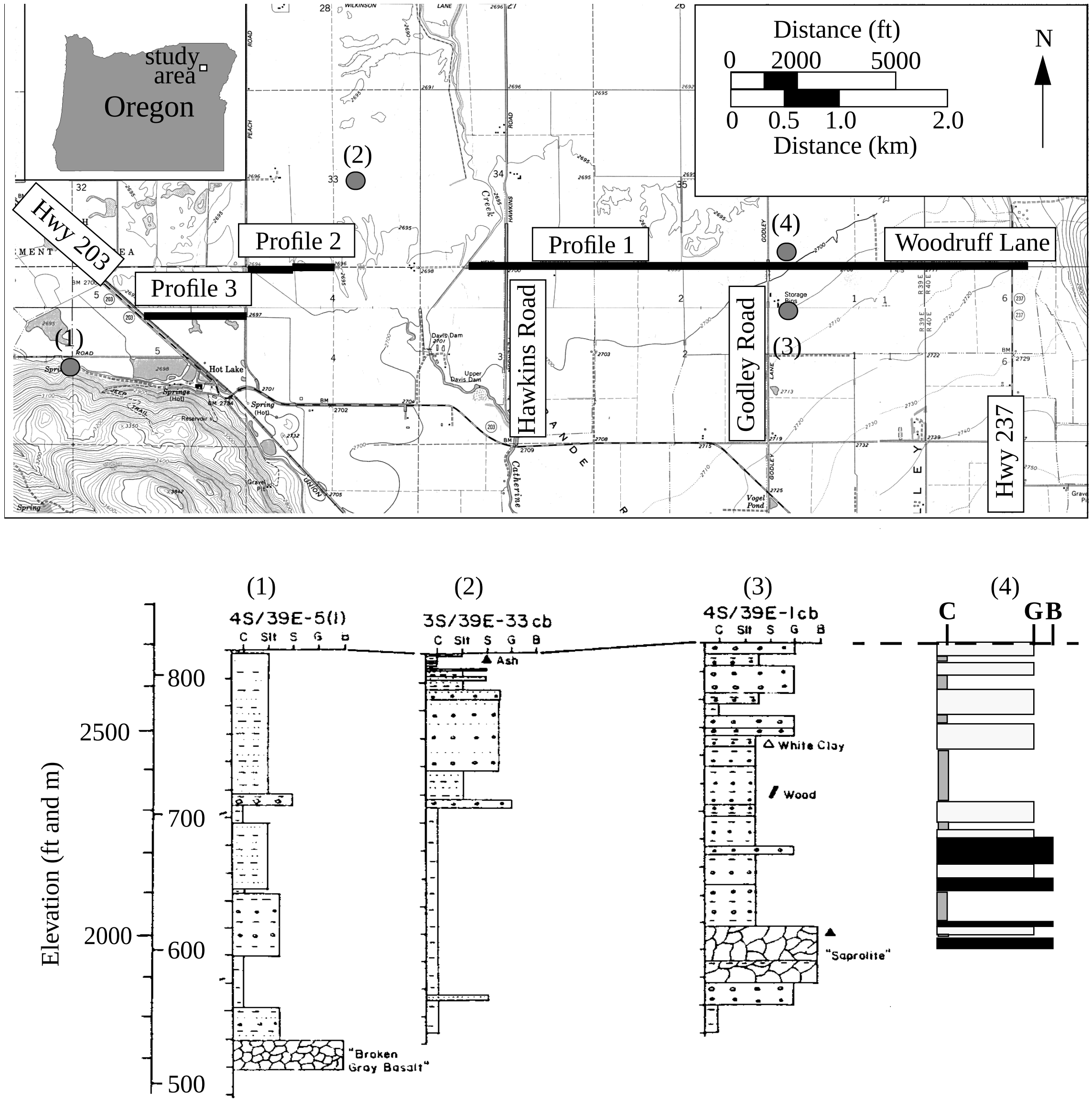

FIGURE 2. Topographic map of the study area and selected lithologic logs from nearby wells. Seismic line locations are noted. Note: Well locations are not precise, but are located in the proper township, range and section. Well logs 1-3 provided by J. Van Tassell. C=clay, Slt=silt, S=sand, G=gravel, B=boulders.

increase in depth between well #3 and well #4) and north of the western portion of our transect.

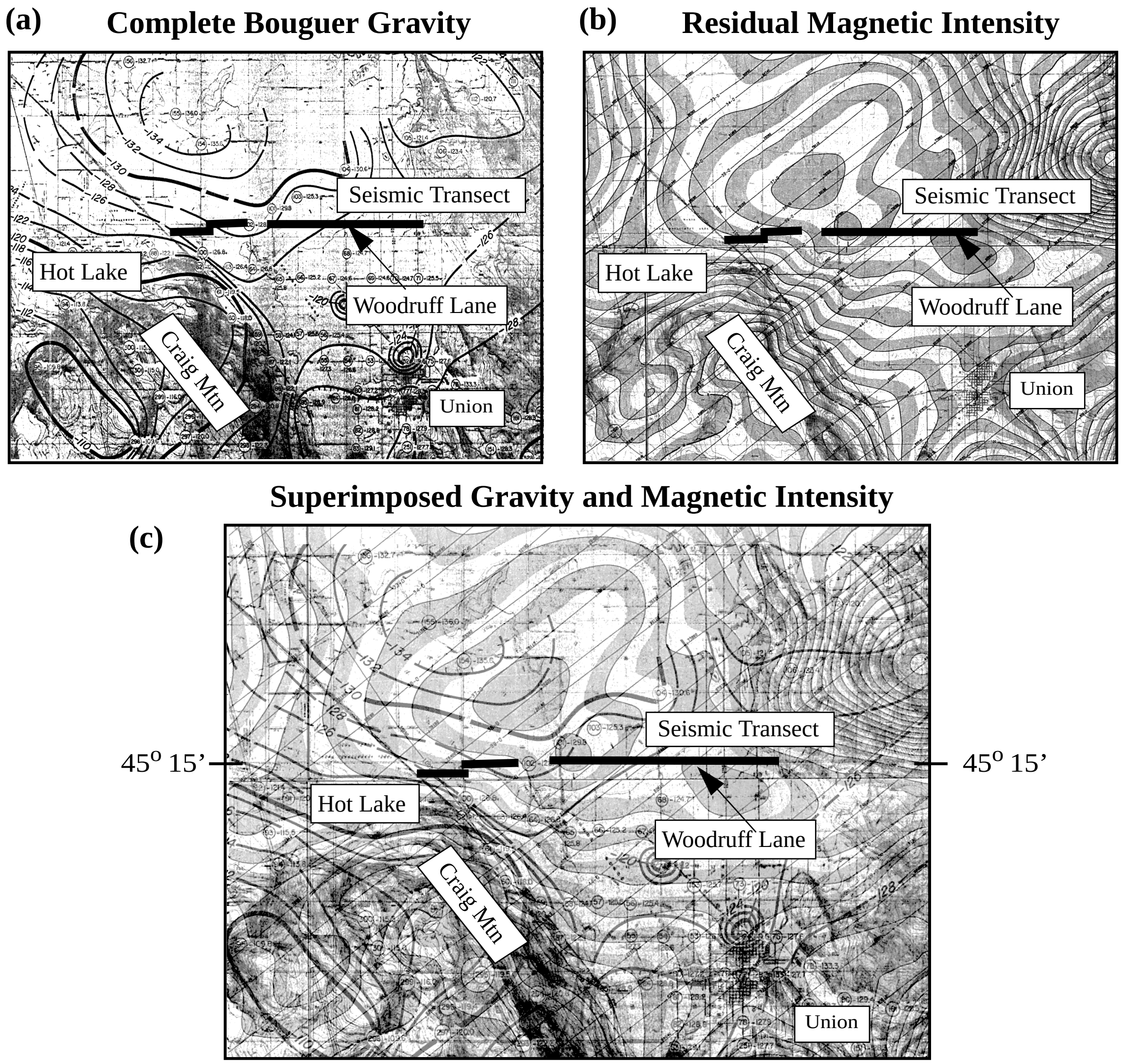

FIGURE 3. Potential field maps for the southern portion of Grande Ronde Valley. Seismic line locations are shown with bold lines. (a) Complete Bouguer gravity map for southern Grande Ronde Valley. Note the large gravity low north of Hot Lake. Local gravity lows east of Craig Mountain are likely spurious single point anomalies. (b) Residual magnetic intensity map for southern Grande Ronde Valley. Lines traversing northeast/southwest are flight lines; shaded contours represent the magnetic signature. Note the large low northeast of Hot Lake and another local low south of Woodruff Lane. (c) Superimposed gravity (bold contours) and magnetic (shaded contours) maps from (a) and (b). The combined gravity and magnetic lows suggest an increase in depth to the denser and more magnetic basalt beneath the less dense and less magnetic sediments of the overlying basin fill. (Figures modified from AMAX Exploration, Inc., 1975)

4.0 Seismic Results

4.1 Seismic Acquisition

We used a 120-channel, 24-bit Geometrics seismograph with 2-m station spacing and up to 120 m shot-to-receiver distances for Profiles 1 and 2, and 4-m station spacing and up to 240 m shot-to-receiver distances for Profile 3. We recorded each gather using a

0.25 ms sample rate for 0.5-0.7 seconds. A trailer-mounted, 320-lb rubber-band-accelerated hammer surface source was used to generate energy at station midpoints. At each source position, the hammer would strike a 1 inch steel plate up to 9 times. Station locations were surveyed with a Topcon total station. We opted for larger station spacing along Profile 3 to account for the increased travel time (depth) of reflections on the field records. Generally a larger station spacing results in less fold (or coverage) on the upper reflections, but this change in station spacing was necessary to image the complete sedimentary and upper hard rock section (primarily due to the dispersive nature of surface waves that interfere with near-offset data).

4.2 Processing

The seismic reflection data were field monitored and processed using Landmark's ProMAX seismic processing package on a UNIX workstation. We combined the raw data into a SEGY seismic file and assigned station locations and shot and receiver elevations. After designing and applying a deconvolution operator to increase resolution and remove short-period multiples (generally originating from the near surface), we removed noisy traces and muted ground roll, refractions, and air wave energy. Next, we binned and sorted the data into common mid-point (CMP) gathers and applied elevation statics. An iterative, interactive velocity routine was used to correct for normal moveout (NMO), the geometry effect of shots and receivers with different offsets. Once we selected a velocity model for each CMP location, we applied NMO, a bandpass filter, and stacked the data. To retain amplitude information, we used an amplitude recovery routine to counter energy loss due to geometrical spreading and acoustic attenuation.

4.3 Profile 1

Seismic Profile 1 begins with source points at Hwy 237 and with geophones placed along the Woodruff Lane shoulder every 2 m. The line progresses west from Hwy 237 to a bridge at Catherine Creek (west of the Hawkins Road intersection). Land access was not permitted beyond Catherine Creek.

Strong, laterally continuous reflections appear from 30-120 ms on the eastern portion of the profile to greater than 300 ms on the western portion of the profile (Figure 4). Each reflection appears to increase in travel time (depth) towards the west with an overall apparent dip of approximately 2 degrees and with an apparent westward thickening of seismic stratigraphic units. Disruptions in lateral continuity occur at approximately CMP 750, 1190, and 1840, and a change in reflection dip occurs at approximately CMP 3350.

The most prominent break in lateral stratigraphic continuity (CMP 1840) correlates with the projected location of the Little Creek fault (Gehrels, 1981; White, 1981) on the profile. Diffractions cross on the unmigrated section at this location, suggesting a lateral, near-vertical break in the geologic horizons. The reflections appear to be offset down to the east approximately 25 m at this location, which is consistent with the sense of movement on the Little Creek fault. Also, evidence of movement appears on reflections as shallow as 40 m depth (as shallow as confidently imaged). A sedimentation rate of 4 m/1000

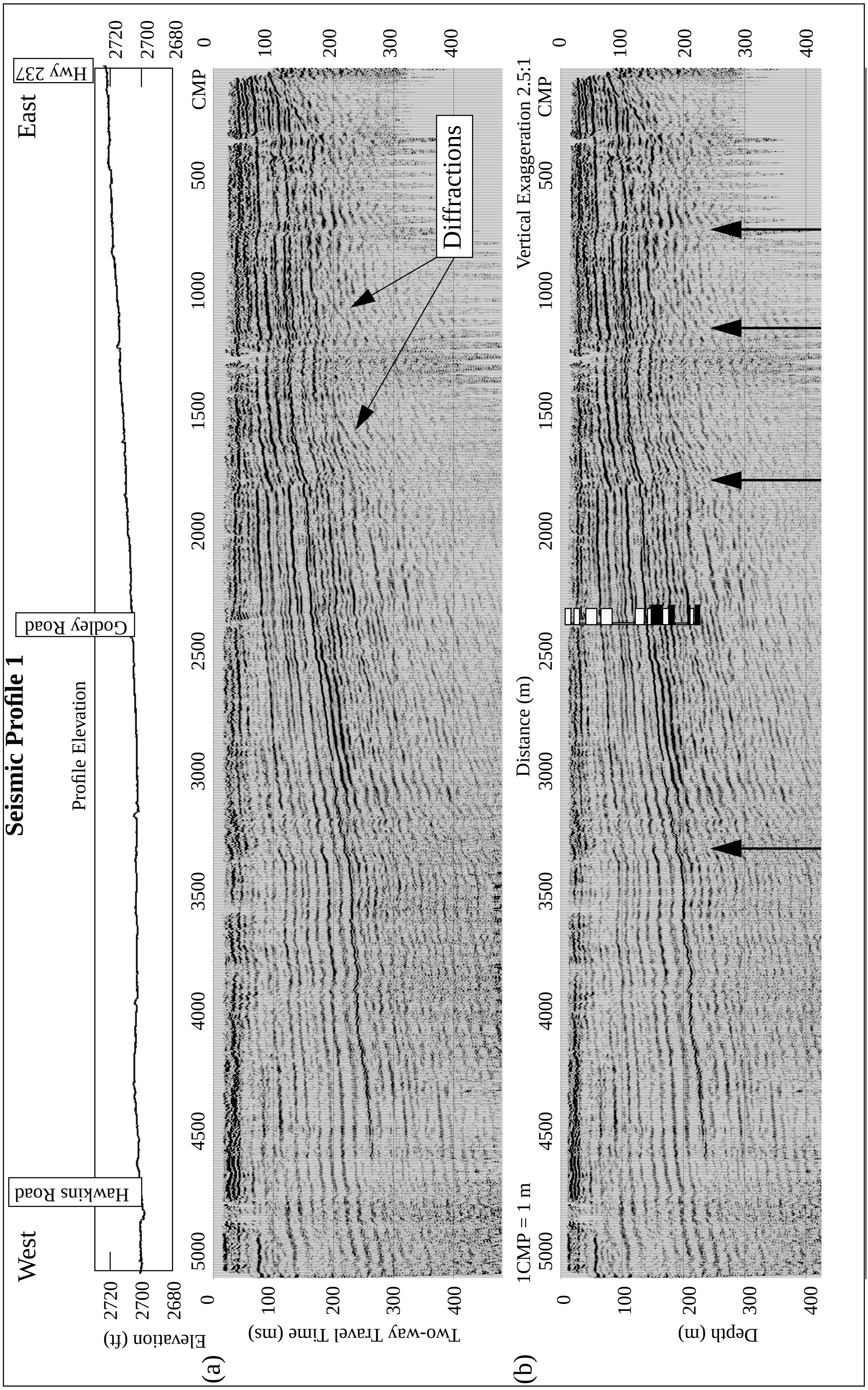

FIGURE 4. Preliminary unmigrated seismic Profile 1 along Woodruff Lane from Hwy 237 (east) to Catherine Creek (west); (a) Time section. (b) Depth section. Note arrows at distinct changes in lateral reflection continuity (see discussion in text). Lithologic log is well # 4 from Figure 2.

yrs during the Pleistocene (Bishop, 1992; Van Tassell and Fromwiller, in review) suggests that the fault has been active until at least 10,000 years before present. Additional near-vertical breaks in the seismic section correlate with unnamed faults in the adjacent ranges (White, 1981) and with the structural grain and general sense of movement in the region (Barrash and others, 1980; 1983; White, 1981; Walker and MacLeod, 1991).

We superimposed a lithologic log from a local well (Well #4 on Figure 2) to correlate reflections to specific lithologic contacts on the seismic depth section (Figure 4) at CMP 2400. The reflection associated with the upper volcanic contact correlates with the deepest coherent reflection that is traceable across the section. Below this reflection, large amplitude but less-continuous reflections appear, and are likely associated with interbedded sediment and volcanic rock units, and with seismic energy trapped between interbeds (short-period multiples). These reflections attenuate to the east, perhaps suggesting sedimentary interbeds diminish toward the eastern range front. Reflections in the upper portion of the sedimentary section correlate with coarse-to-fine grained sediment contacts (e.g., 55 m and 65 m depth). Also note the low angle reflection that appears on the eastern portion of Profile 1 (CMP 50-400). The seismic signature of this arrival differs from the diffractions observed to the west (Figure 4) and may represent a structural or stratigraphic feature.

4.4 Profiles 2 and 3

Seismic Profiles 2 and 3 continue westward from Profile 1 after a 1609 m or 1 mile gap (Figure 2). Profile 2 is 800 m long (1/2 mile) and could not continue west of Peach Road due to vehicle access problems in the marshy area. Profile 3 is offset southward approximately 0.5 km from Profile 2. Seismic Profile 3 terminates at the berm east of the railroad tracks that parallel Hwy 203. Source points were located between geophone locations on both profiles. We extended the station spacing on Profile 3 after recognizing an increased travel time to the large amplitude reflections from Profile 2.

Reflections on Profile 2 appear relatively flat-lying, but an increase in dip appears along Profile 3 (Figure 5). Both profiles contain a large-amplitude, continuous reflection package at 80-100 m depth. This reflection package is likely associated with a change from course-grained, near-surface material to finer-grained, underlying sediments, as observed in well # 2 (Figure 2). This sequence may be traced along the upper portion of Profile 1 and perhaps extends as far east as CMP 2000. Below the large amplitude reflection package, an interval that is up to 200 m thick contains relatively few continuous reflections. This correlates with the near-continuous clay sequence recorded on Well # 2 (Figure 2).

Below 250-300 m, strong continuous reflections appear again, suggesting alternating course- and fine-grained sediments or sedimentary interbeds between volcanic units. We suspect the reflections at 300 m depth on Profile 2 and from 250-300 m depth on Profile 3 may correlate with the sediment/volcanic rock contact, although the exact correlation of the contact between Profile 2 and Profile 3 is difficult to pinpoint because of the difference in signal strength and data quality between them. The decrease in depth to this horizon to the south, along Profile 3, and at the Hot Lake walkaway test site (Liberty and

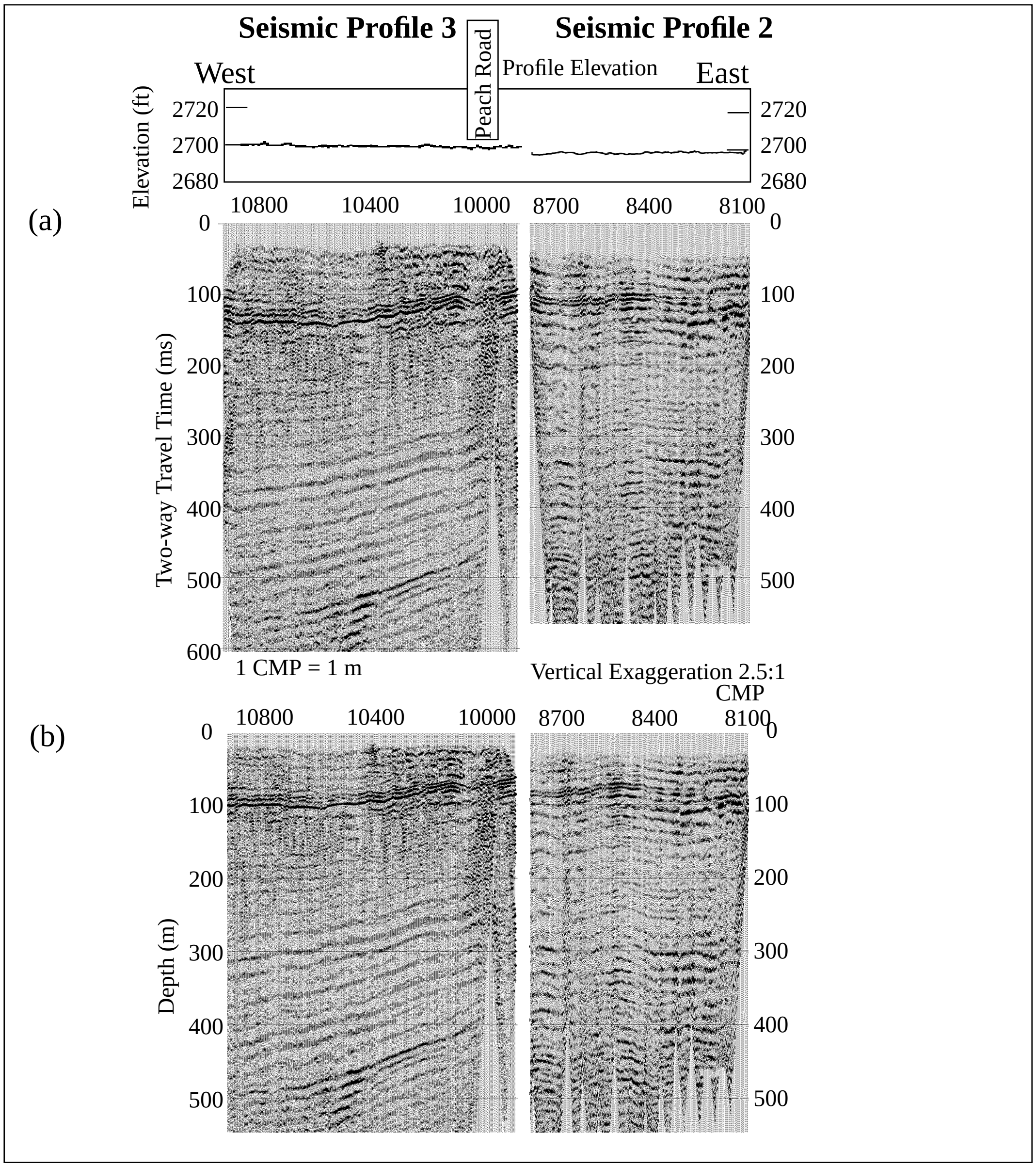

FIGURE 5. Preliminary unmigrated seismic Profiles 2 and 3. (a) Time section. (b) Depth section. Note the dip change between Profile 2 and Profile 3 on the section below 200 m.

others, 1998) may be due to structural complexities close to the range front (Craig Mountain). However, the reflections still appear to dip to the west along Profile 3 (steeper on the eastern portion of the profile), suggesting a fault closer to Craig Mountain or a change in geologic dip, as we observed at the Hot Lake walkaway seismic test (Liberty and others, 1998). Reflections below this upper contact on Profile 3 may correlate with deeper volcanic units or interbedded volcanic rock and sediments. Also, due to the likely oblique orientation of the seismic profile with respect to the true geologic dip (we estimate a 6 degree apparent dip between CMP 8750 on Profile 2 and CMP 9990 on Profile 3), energy from out-of-plane geologic strata may appear on the profiles.

5.0 Summary

The seismic reflection transect across southern Grande Ronde basin shows a continuous package of sediments across the valley, though varying in lithology both laterally and vertically. The seismic results are consistent with gravity and magnetic data from the region. The sedimentary/volcanic rock contact across the valley deepens to the west on all profiles and may shallow to the south near Craig Mountain. Near vertical faults and the distribution and continuity of coarse- and fine-grained sediments in the valley will influence groundwater flow, and thus provide constraints on a groundwater model for the valley.

6.0 Acknowledgements

Project support was provided by Department of Geology and Mineral Industries. Discussions with Ian Madin, Mark Ferns and Jay Van Tassell helped shape this report. Field assistance was provided by students from Boise State University and Eastern Oregon University.

7.0 References

AMAX Exploration, Inc., Residual magnetic intensity map and complete Bouguer and terrain corrected gravity map, Denver, CO, 1975.

Barrash, W., Bond, J.G., Kauffman, J.D., and Venkatakrishnan, R., 1980, Geology of the La Grande area, Oregon: Oregon Department of Geology and Mineral Industries Special Paper 6, 47 p.

Barrash, W., Bond, J.G., and Venkatakrishnan, R., 1983, Structural evolution of the Columbia Plateau in Washington and Oregon, American Journal of Science, v.283, p. 897-935.

Bishop, E.M., Thompson, L.L., and Woodward, J., 1992, Sedimentation and tectonics in the Grande Ronde graben, northeast Oregon: A preliminary assessment: *Geological Society of America* Abstracts with Programs, v. 24, no. 5, p. 7.

Gehrels, G.E., 1981, The geology of the western half of the La Grande basin, northeastern Oregon: M.S. Thesis, University of Southern California, 87 p.

Liberty, L., Barrash, W., and Bolger, R.D., 1998, Southern Grande Ronde Valley seismic project - phase I: walkaway tests: Technical Report BSU CGISS 98-04, Boise State University, Boise, ID, 12 p.

Van Tassell, J. and Fromwiller, G., in review, A 450,000 year record of glaciations and climate from the LaGrande Basin, northeast Oregon, submitted manuscript.

Walker, G.W., and MacLeod, N.S., 1991, Geologic map of Oregon, U.S. Geological Survey, 2 sheets.

White, R.R., 1981, Structural geology of the eastern half of the La Grande basin, northeastern Oregon: M.S. Thesis, University of Southern California, 133 p.