Contribution to the Treasure Valley Hydrologic Project -1997

STRUCTURE CONTOUR MAP OF TOP OF THE MUDSTONE FACIES, Western Snake River Plain, Idaho

By
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August, 1997

Boise Map Sheet, Idaho: Scale = 1:100,000
Elevations in feet with respect to sea level
Contour Interval = 100 feet (contours dashed where uncertain for lack of control wells)

Doty '79 ○ = **deep water well used for control, giving name of owner listed on driller's log, and date of completion.**

Oroco Oil and Gas Cleveland #1 (T.D. 4038 ft) ◇ = **deep petroleum or geothermal exploration well, giving operator, lease name, and total depth**

= **edge of sedimentary basin**

= **approximate trace where contact is at the surface (i.e. the contact between the fluvial-deltaic section and the underlying mudstone skylights in the Snake River Canyon)**

Introduction

The most important hydrogeologic facies boundary recognized in the western plain is the contact of the fluvial deltaic section overlying a thick section of prodelta and deep-lake mud facies that fills the western plain. It is recognized in every exploration well west of 116° 30'E deeper than 2000 feet (Figure 1). Few or perhaps no water supply wells have drilled through the contact in this area, as adequate transmissivity usually occurs within the first 500 to 1200 feet. East of of 116° 30'E the mudstone facies becomes increasingly more sand bearing. Furthermore, the northeast margin of the basin has apparently uplifted, or is less compacted – so that the contact likely slopes upward to the east and grades eastward into an erosional unconformity as suggested by Squires and other (1992, p. 29). Although an angular discordance of a few degrees may occur at the unconformity, it has not been recognized in wells. In many areas there may be no discordance, but I believe study may show course sediments over fine deeper water facies as an indicator.

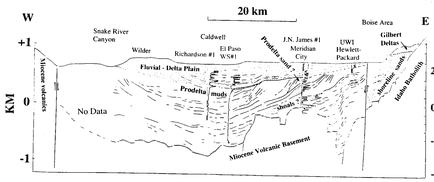


Figure 1. East–west cross-section of the western Snake River Plain showing configuration of strata interpreted from seismic reflections (Chevron Seismic Line IB-2 and Lariat Exploration Seismic Line BB2) and showing location of sand aquifer systems identified by geophysical logs of deep wells. Resistivity logs are shown for 4 wells. Excursions on log trace to the right indicates sand aquifers, and low resistivity values to the le't indicates clayey muds of low permeability. Vertical Scale is greatly exaggerated, so that the inclination of strata is incorrectly shown as being steep, whereas in reality the inclination from horizontal (dip of strata) is everywhere less than 6 degrees.

Data used for structure contours

The electric logs from deep petroleum and geothermal wells clearly show the vertical facies change from a predominantly mudstone section upward to sands of river deltas and fluvial systems (Wood, 1994). The contact can be reliably picked from the geophysical logs of 9 deep wells on the Boise 1:100,000 sheet and at elev. 1635 feet in the Rube Bolles #1 well near Payette (illustrated on the Ontario cross section by Beukelman (1997)). The key to identification of the contact is the subtle upward coarsening of the mudstone, and then an abrupt change to sand, features shown by Wood (1997) to be characteristic of the pro-delta facies. The contact can be identified from the clinoform character of seismic reflections of the prodelta facies using high-resolution seismic profiling; however, only parts of Chevron IB-2, and Intermountain Gas Corp. seismic data have been processed to resolve the shallow section (shallower than 1200 feet). Long offset seismic spreads on all but the Intermountain Gas data [published by Wood(1994)]preclude resolution of the section shallower than 1000 feet.

It is reasonable to assume that the contact conforms with seismic reflections, but on most lines it occurs too shallow to be resolved. On the other Chevron lines, the Champlin, Amchatz, and Lariat Exploration data the shallowest reflections have been interpreted, and their configuration extrapolated upward to tie to the depths of the contact in the wells (known as construction of a "phantom horizon" in seismic interpretation methodology). Seismic times to the "phantom horizon" representing the mudstone contact were converted to depth using a velocity of 6,000 feet/second. This velocity is based upon the only reliable sonic logs for the shallow section in the basin: the Higgenson Well, 4 miles west of Meridian and the Highland L & L well 5 miles north of Parma. Sonic log of the Highland L & L (the water saturated section below 300 feet) indicates a velocity of 5830 ft/sec for sediments in the upper 1000 feet. The Higgenson sonic log indicates a velocity of 6100 feet/second for the upper 1000 feet – so it was decided to use 6000 feet/second for all of the data. A velocity of 7000 ft/second used for static corrections in processing by Chevron and Lariat worked for low resolution data, but is incorrect and too high a value. Chevron used a 2500 foot datum, and Lariat a 2300 foot datum. I was able to tie the lines by adding 50 milliseconds time to the Lariat data. Processing parameters of the Anschutz and Champlin data are unknown, but were satisfactorily tied to Chevron data by adding a constant to the reflection time.

The water well locations posted on map are those in cross sections prepared by Beskelman (1997) and Hold (1997) for this project. Few if any of these water wells penetrated the contact because drillers seldom continue through more than 100 feet of mudstone, if they can make a well in the previously drilled section. However on the margins of the plain, it appears some wells penetrate the contact.

The monitoring well in the Canyon County Pickles Butte Landfill (PB-2) cored through the contact at elevation 25'.0 (Hold, 1997, Profile H). Exposures along the Snake River Canyon southeast of Marsing and the sections described by Repenning and others (1995) indicate that the contact is exposed in the canyon in this area. On the northwest side of the plain, along Willow Creek, about 4 miles north of Star, the Little Cattle Company well drilled into 50 feet of mudstone at elevation 2050 feet. Three miles to the northwest, the Land well drilled 350 feet of "blue-gray clay" below elevation 2340 feet.

Structure contours north of 43°45' (i.e. Parma – New Plymouth area) are based upon 4 widely spaced wells and are not controlled by seismic data. Donation of three proprietory seismic lines covering that area have been requested from Amoco Production Company (Denver and Houston offices), but at the time of writing the request has not been acted upon.

Little information is available on the elevation of the contact in the Murphy quadrangle and Mountain Home area of the Treasure Valley Hydrologic Project. Much of the area is covered with Quaternary basalt (Wood, 1997c) and there are few deep wells. Therefore a map was not produced for the mudstone contact in that area. I have received sample parts (to consider for data purchase*) of a Pretu-Ray (Halliburton) seismic line, run in 1982 between Mora and Blacks Creek Reservoir. The seismic data indicate a thick sedimentary section, perhaps 7000 feet thick, dipping gently to the west – and the data possibly could be purchased and reprocessed for information on the upper aquifer section.

In the deepest well (Mountain Home Air Force Base) the sedimentary section between depth 535 ft and 1927 feet is most likely the lacustrine section (Lewis and Stone, 1988). Lithology was inconsistently logged, but a cored section may still be available from the USGS for restudy. The gamma log shows an abrupt increase in counts at 1140 feet, which might be the top of the mudstone, and part of the section was logged as calcareous clay and silt. That gamma-ray contact would correspond to an elevation of 1880 feet. The Cunningham well, 6 miles southeast of Orchard drilled beneath the Quaternary basalt into 250 feet of sandy sediment down to elevation 1820 feet, but is apparently still in the fluvial section. The USAF Missile well 2 miles northeast of Orchard drilled 1200 feet through materials described mostly as silt and shale, but sand units occur throughout the section down to elevation 2100 feet.

Exposures of the Glenns Ferry Formation along the Snake River Canyon of the Murphy area have not been mapped in a detail adequate to identify facies units, but most published descriptions are of sandy sediments, without a clear boundary of a mudstone unit.

Hydrogeologic Significance

The section of fluvial-deltaic facies above the mudstone contact is typically 800 to 1500 feet thick, and contains the major sand aquifers for water supplies from the western plain. Exception is in the City of Boise area, where some of the deep wells are surely producing from below the unconformity, from sands equivalent in age to the mudstone facies.

Other workers have searched without convincing results for meaningful lithologic boundaries, and broadly distributed "blue clay" units within the fluvial-deltaic section. I think it unlikely that such broadly distributed units of low permeability exist in the section. Some mudstone (including clay and silt) layers can be traced within the fluvial-deltaic section for several miles, but not regionally. Instead it is likely that over a broad region there is some vertical continuity in the section – although some local aquifers do contain unusual water chemistry (Ed Squires, personal communication) indicating some degree of local isolation by aquitards.

Individual lacustrine mudstone units can be many hundreds of feet thick, locally separated by thin fine sand units, probably of density-flow origin. It is unknown whether these sand units in some places up to 30 feet of thin interbedded sand and mud are local occurrences, or whether they extend for many miles. The lithology of the mudstone varies fr- m a calcareous claystone to clayey silt and has low permeability. I have used the collective term mudstone for these clayey units because most have a minor sand fraction in addition to dominant clay and silt. Fifteen laboratory measurements of saturated hydraulic conductivity of silty claystone and claystone were made for studies of the Pickles Butte landfill (Canyon County) and the Clay Butte Landfill (Payette County) and reported by Holliday Engineering (1993). Twelve of these measurements are between 10^{-7} to 3×10^{-7} cm/s while the remainder varied from 10^{-6} to 1.9×10^{-5} cm/s; therefore a value of the order of 10^{-7} cm/s seems appropriate for the upper part of the mudstone unit, which is surely several orders of magnitude lower than most of the overlying fluvial-deltaic section.

Structural relief on the upper mudstone contact

The contact is broadly downwarped toward the middle of the western Snake River basin, being about elevation 2500 feet on the margins, and about elevation 1200 feet near the center of the basin, seven miles north of Caldwell. Another northwest trending low area is between the cities of Nampa and Caldwell, where the surface is slightly below 1300 feet elevation. Broad downwarping toward the center of the plain probably has a tectonic component, but much of the relief within the center of the basin may be on account of compaction of underlying sediments. The relatively high nose extending from the Meridian area to the Sundance Hunter-Linning well, 5 miles northwest of Caldwell, is produced by compaction draping over a subsurface structural high. This has produced relief from 200 to 400 feet from the high to the adjacent low areas.

Faulting does not appear to have significantly affected the surface. Faulting with displacements less than 100 feet are observed in the mapping or the Ten Mile gravel which overlies the fluvial-deltaic section (Wood and Anderson, 1981, p. 30). Faulting cannot be resolved on the seismic sections on account of low resolution of the data. Beth Hold (1997) and Beskelman (1997) inferred faults to explain shifts in units they believe to be correlative, but displacements are probably small, and in some cases alternative explanations (such as channel infilling) may account for the shifts.

Geological Significance of the fluvial-deltaic / mudstone contact

This compilation of elevation data on the top contact of the mudstone unit has significantly advanced the understanding of the lacustrine sediments of the western plain. The overlying fluvial-deltaic section is generally regarded as the Glenns Ferry Formation which had previously been studied only southeast of Grandview, and along the Snake River Canyon east to the Hagerman area and reported in many publications referenced in H.E. Malde (1991). My present concept is that Lake Idaho began to overflow into the ancestral Hells Canyon drainage at the *beginning of Glenns Ferry time* (Wood, 1997a). Gradual downcutting of the new outlet caused a more rapid progradation of deltaic sediment into the basin formerly occupied by deeper parts of Lake Idaho – and this explains the widespread contact between the deepwater mudstone and fluvial-

Ohlberg, K.L., 1994, Geology and geomorphology of the Boise Valley and adjoining areas, western Snake River Plain, Idaho: Idaho Geological Survey Bulletin 29, 54 p.

Repenning, C. A., Weaver, T.R., and Scott, G.R., 1995, The early Pleistocene (latest Blancan – earliest Irvingtonian) Froman Ferry fauna and history of the Glenns Ferry Formation, southwestern Idaho: U.S. Geological Survey Bulletin 2105, 86 p.

Schumm, S.A., and Etheridge, F.G., 1994, Origin, evolution, and morphology of fluvial valleys; in Dalrymple, R.W., Boyd, R., and Zaitlin, B.A. eds., Incised-valley systems: origin and sedimentary sequences, Special Publication No. 51, SEPM (Society for Sedimentary Geology), Tulsa, p. 11-27.

Thompson, R.S., 1991, Pliocene environments and climates in the western United States: Quaternary Science Reviews, v. 10, 115-132.

_____1996, Pliocene and early Pleistocene environments and climates of the western Snake River Plain, Idaho: Marine Micropaleontology, 27, p. 141-156.

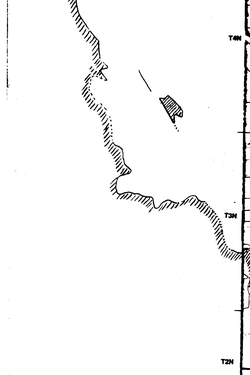
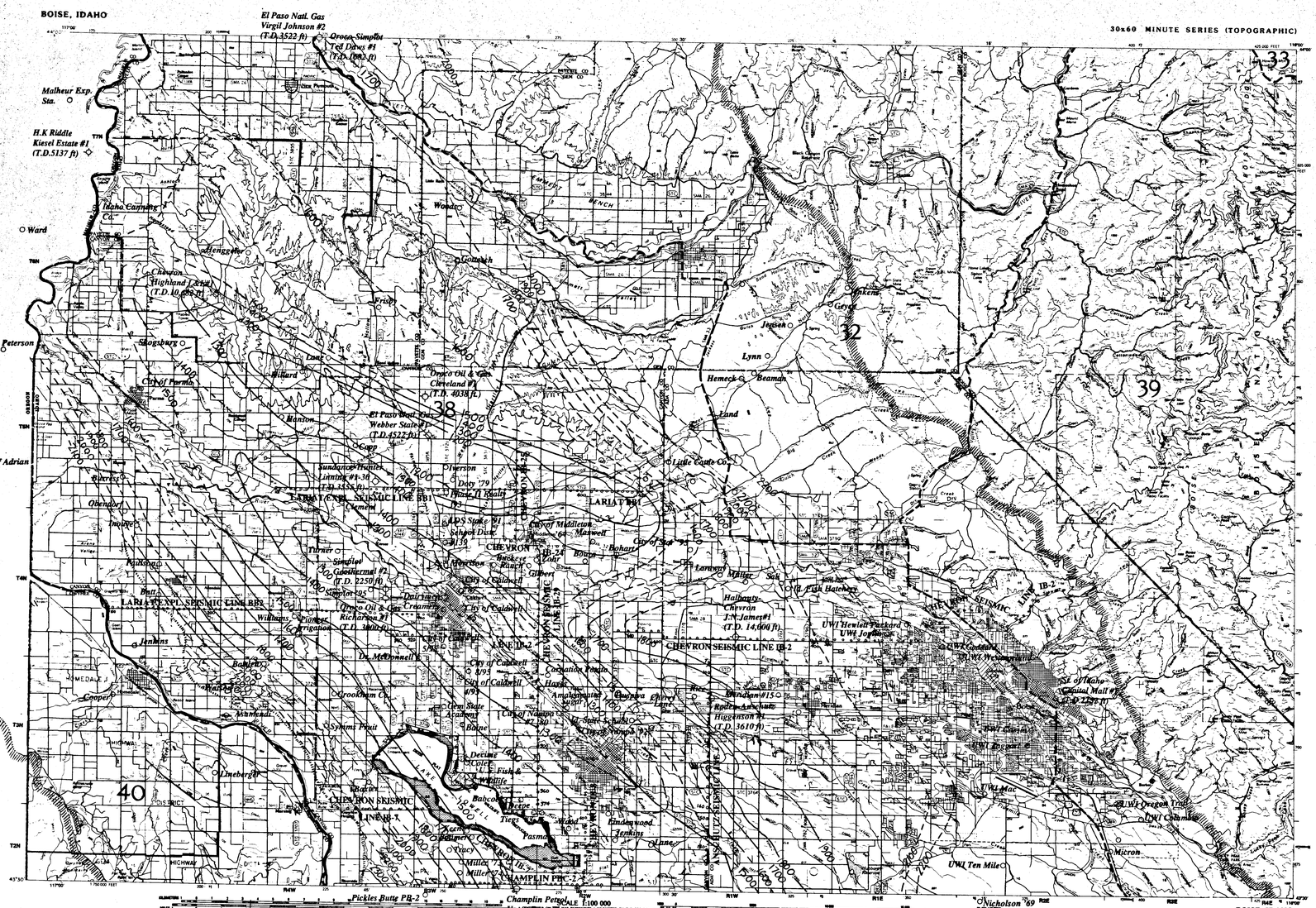
Whitehead, R.L., 1992, Geohydrologic framework of the Snake River Plain Regional Aquifer System, Idaho and Eastern Oregon: U. S. Geological Survey Professional Paper 1408-B, 32 p.

Wood, S.H., and Anderson, J.E., 1981, Geology , in Mitchell, J.C. (ed.) Geological, Hydrological, Geochemical and Geophysical investigations of the Nampa-Caldwell and adjacent areas, southwestern Idaho: Idaho Department of Water Resources Bulletin 30, Part 11, p. 9-31.

Wood, S.H., 1994, Seismic expression and geological significance of a lacustrine delta in Neogene deposits of the western Snake River Plain, Idaho: AAPG Bulletin, v. 78, p. 101-121.

_____1997a, Late Pliocene drainage of Lake Idaho: Geomorphology of the outlet area and subsurface data from the western Snake River Plain, Idaho and Oregon (abs): The Great Basin Symposium on Glacial and Postglacial Drainage (Smithsonian Institution and the University of Utah) Salt Lake City, September, 1997.

_____1997b, Hydrogeologic framework of the western Snake River Plain rift basin, Oregon and Idaho (abs): Geological Society of America Annual Meeting, Salt Lake City, October, 1997.

_____1997c, Structure contour map of the base of the Quaternary basalt, Murphy and the western part of the Mountain Home 1:100,000 quadrangles: 1997 Contribution to the Treasure Valley Hydrologic Project, unpublished report from Boise State University /CGISS and Geoscience Dept.) to the Idaho Department of Water Resources: 1 sheet with text.

*Currently, the brockerage company for purchase of proprietary seismic data in the Rocky Mountain Region is Seismic Data Exchange, Inc., 1776 Lincoln Street, Suite 620, Denver, Co 80203; Mr. Steve Kloppel, (303)832-5007, fax 832-5043.