COLUMBIA BASIN - CONVENTIONAL GAS PLAYS

Dnr.wa.gov/htdocs/sales_leasing/leasing/oilandgas/index

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WASHINGTON STATE DEPARTMENT OF Natural Resources

Play Summary

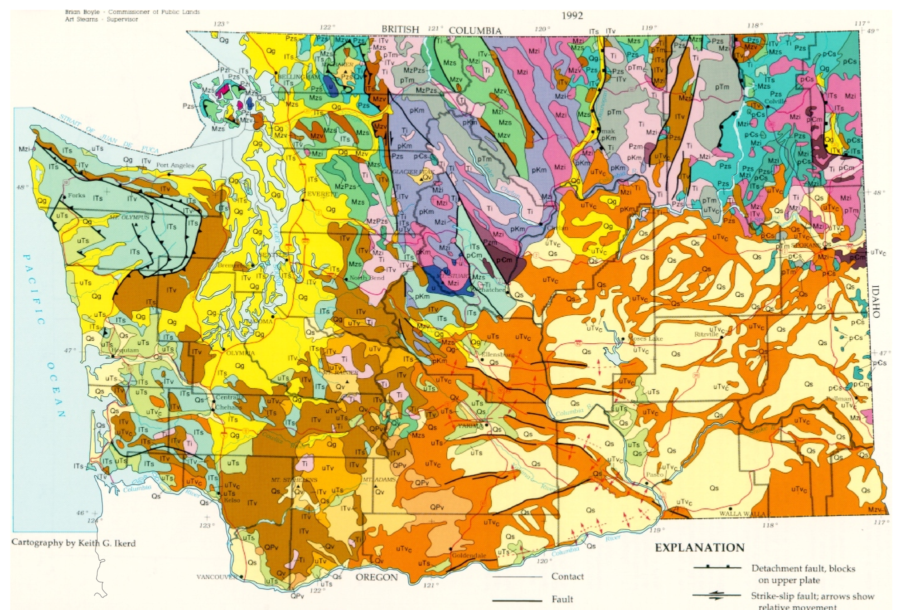

Fig. 1. Geologic map of Washington showing the Columbia Basin (SE/4 of map) and outcrops of Eocene reservoir and source strata (Unit iTs - pale bluish-green).

The Columbia Basin is a 4,000- to >10,000-ft thick sequence of non-marine, Eocene and Oligocene sandstones, coals, and fine-grained siliciclastic rocks overlain by 0- to 16,000-ft of Miocene flood basalts (Figs. 3, 4, 10, 15). While only seven deep wells have been drilled in this large basin (fig. 8) DST results prove that excellent reservoir characteristics (5,400 BWPD) and thermally mature gas-generative source rocks (3.1 MMCFGPD) exist under the basalt (Table 1, Figs. 4, 15). Three plays are apparent:

1) Conventional gas accumulations in large faulted anticlines,
2) Deep, basin-centered gas, and
3) Coalbed methane (in the northwestern-most parts of the basin).

(Potential for all three plays also exist in western and southern Washington.) This poster primarily addresses conventional accumulations, because little effort has been applied to exploring these anticlines, although potential exists for multiple fields, many with possible reserves in excess of 1.0 TCF recoverable gas (Table 2).

The first phase of exploration in the basin (~1975 to 1995) suggested that thick sedimentary sections everywhere underlie the basalt, coincident with the outcrop pattern of a set of very large anticlinoriums known as the Yakima Fold Belt. Most wells had excellent shows, but extended testing failed to establish deliverability at economic rates; this with relatively small fracs and $2.00/mcf gas.

Today Encana and Shell are drilling a wildcat of probable national importance, the Anderville Farms No. 1 (Fig. 2), in an off-structure location. It is likely a test of the basin-centered gas play. They are employing a top-drive reverse-circulating air-lift rig to drill the basalt and are reputedly achieving relatively rapid penetration rates. Their next wildcat, the Anderson No. 1, will be drilled at the culmination of the Rattlesnake Hills anticline.

The Washington State Department of Natural Resources plans lease auctions for June 7 and October 26, 2006, in Room 172 of the Nature Resources Building, 1111 Washington Street SE, Olympia Washington. Information including an extensive bibliography of Washington petroleum geology is available at www.dnr.wa.gov/htdocs/sales_leasing/leasing/oilandgas/index or by calling 360-902-1600.

In the June 7, 2007 lease auction, DNR will probably offer 6-year 12.5% royalty leases in areas selected on the basis of potential for conventional gas accumulations, but also with less obvious potential for CBM and basin-centered gas. In October, DNR plans to auction newly expired leases in the central Columbia Basin in areas adjacent to the recent wildcats and with demonstrable potential for basin-centered gas. Interested parties are also encouraged to nominate any other State land for inclusion in the auction using the process outlined in the above website.

Table 1: Columbia Basin Shows

Quincy No. 1 (Shell Western E & P, Inc.)

Perforations from 8,765 to 8,915 ft and 8,779 to 8,886 ft produced gas TSTM and 500 BW.

23-35 BN [Boylston Mountain well] (Meridian Oil, Inc.)

Drillstem test from 11,919 to 12,584 ft. No data reported. Abundant cutting gas shows throughout the Paleogene nonmarine section.

BN 1-9 [Saddle Mountains well] (Shell Western E & P, Inc.)

12 gas zones reported. 4 production tests. Acidized and fraced perforations from 12,694 to 12,699 ft produced 2.4 MMCFGPD and 134 BWPD with 985 psi FTP on 20/64-inch choke. A test through casing from 13,372 to 13,388 ft. produced 3.1 MMCFGPD and 6 BCPD with 3,965 FTP on 10/64-inch choke.

Bissa 1-29 [Whiskey Dick well] (Shell Oil Co.)

Acidized perforations from 10,314 to 10,898 ft, 9,436 to 9,830 ft, and 8,486 to 8,800 ft flowed gas TSTM.

Yakima Minerals 1-33 [Rosa Dam well] (Shell Oil Co.)

Acidized perforations from 15,466 to 15,540 ft recovered small amounts of gas. Perforations from 12,976 to 13,568 flowed 570 MCFGPD and 5,400 BWPD with 3,250 psi FTP on 24/64-inch choke. Fractured and acidized perforations from 12,450 to 12,460 ft and 12,350 to 12,360 ft flowed 500 MCFGPD. Acidized perforations from 11,676 to 11,686 ft, 11,564 to 11,574 ft, and 11,598 to 11,652 ft flowed gas at 85 MCFGPD. Perforations from 10,604 to 10,930 flowed 10 MCFGPD. Perforations from 7,535 to 8,040 ft flowed 1,700 BWPD and 27 MCFGPD.

Norco No. 1 [Wenatchee well] (McFarland, 1983)

Gas shows reported.

Rattlesnake Hills Gas Field (Hammer, 1934)

Produced 1.3 BCF gas from 16 wells producing between 700 and 1,200 ft at 7 psi FTP. Gas was piped to Yakima for sales.

Water Wells (Johnson and others, 1993)

19 water wells between Yakima and Pasco have tested apparent thermogenic gas and several have had degassing equipment installed.

Fig. 2. The Anderville Farms No. 1, Grant County. This wildcat, drilling in a large synclinal valley, appears to be the first basin-centered gas test in Washington.

Reservoirs

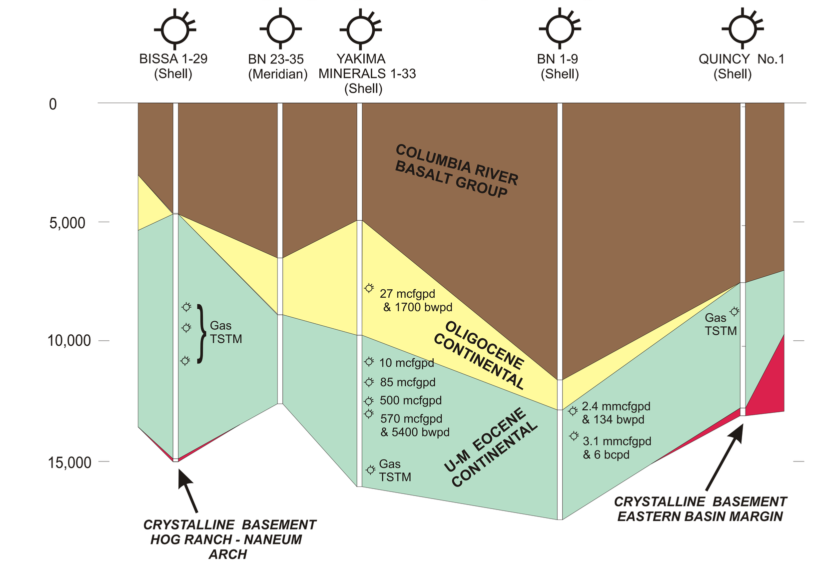

Fig. 3. Simplified north to south stratigraphic cross section (on top, Middle Miocene flood basalt) showing some drillstem test results.

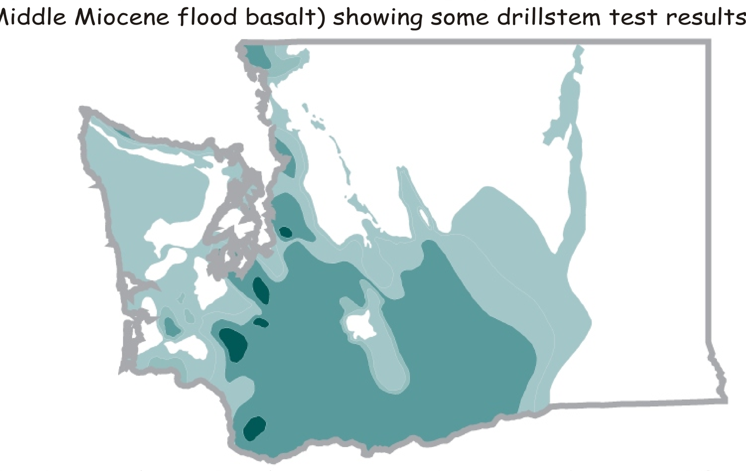

Fig. 4 Speculative formline contours showing thicknesses of Eocene strata in Washington State (Lingley, 1995). This interpretation includes basin-fill volcaniclastic rocks. C. I. = 5,000 ft.

Fig. 5. Typical western Washington Eocene coal/sandstone couplet mined on the flank of a small anticline. The scum in the pond is actually methane bubbles. The coalbed is about 50-ft thick. Note that coalbed methane potential exists in northwest Columbia Basin rhombochasms.

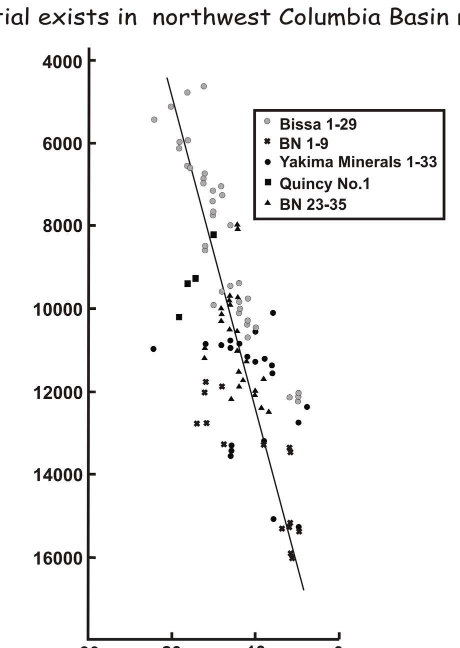

Fig. 6. Porosity-Depth plot for feldspathic sandstones >10-ft thick in Columbia Basin wells (Lingley and Walsh, 1986).

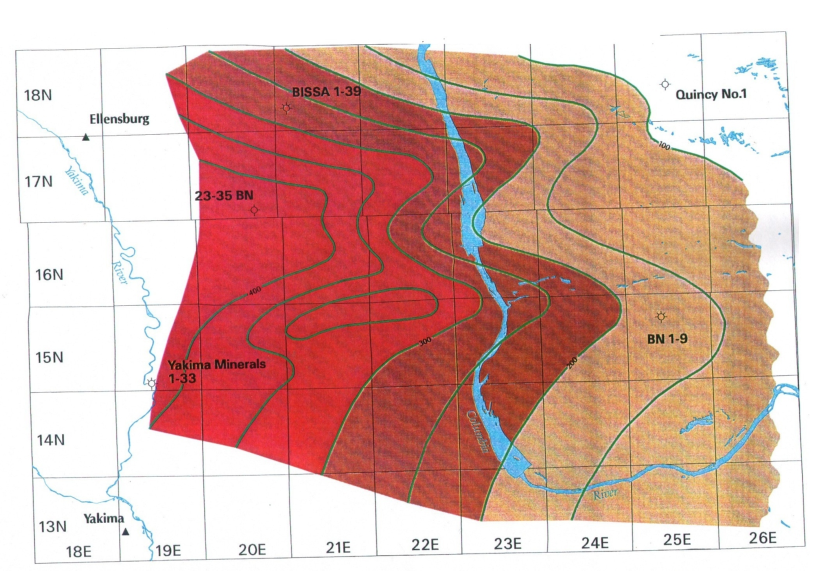

Fig. 7. Aggregate thickness of Columbia Basin sandstones. Contour interval = 50-ft (Lingley, 1995).

Structure

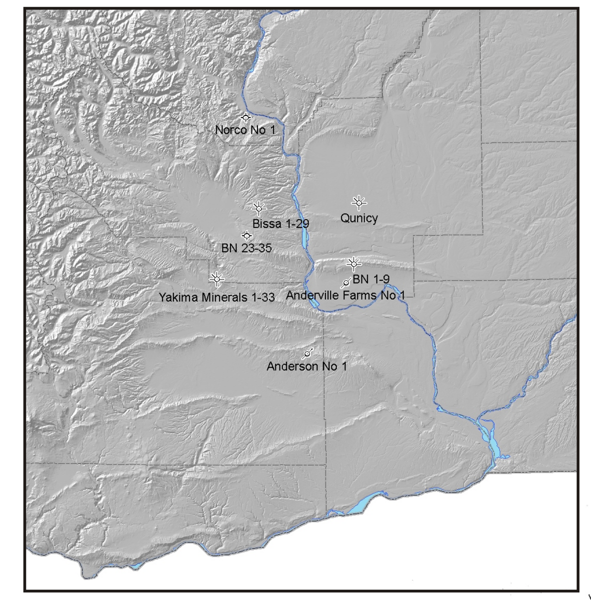

Fig. 8. DEM topography of the northwestern Columbia Basin showing key wells and the Columbia and Snake Rivers.

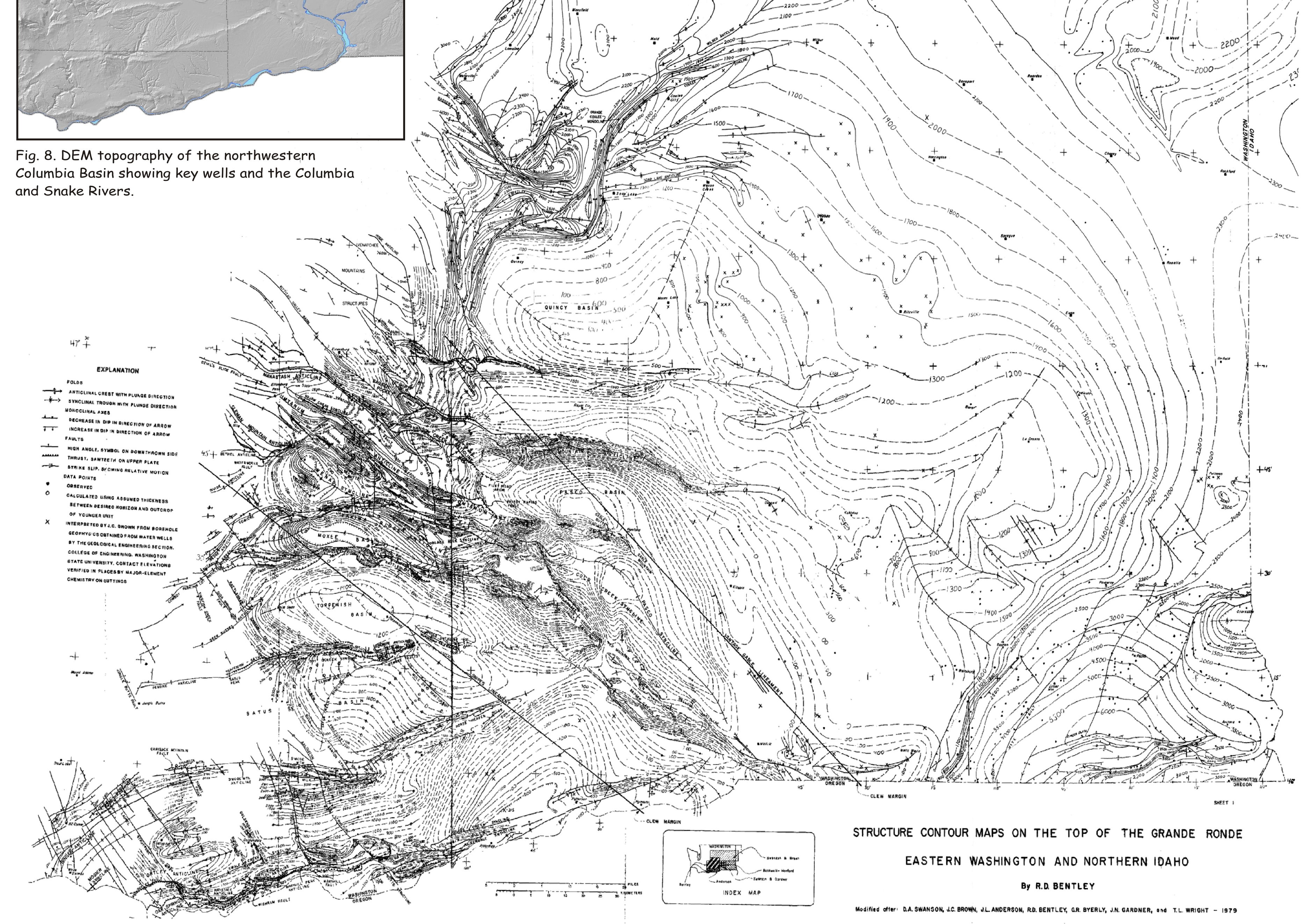

Fig. 9. Structural contours on the Grande Rhonde Basalt (near surface) by Bentley (1980).

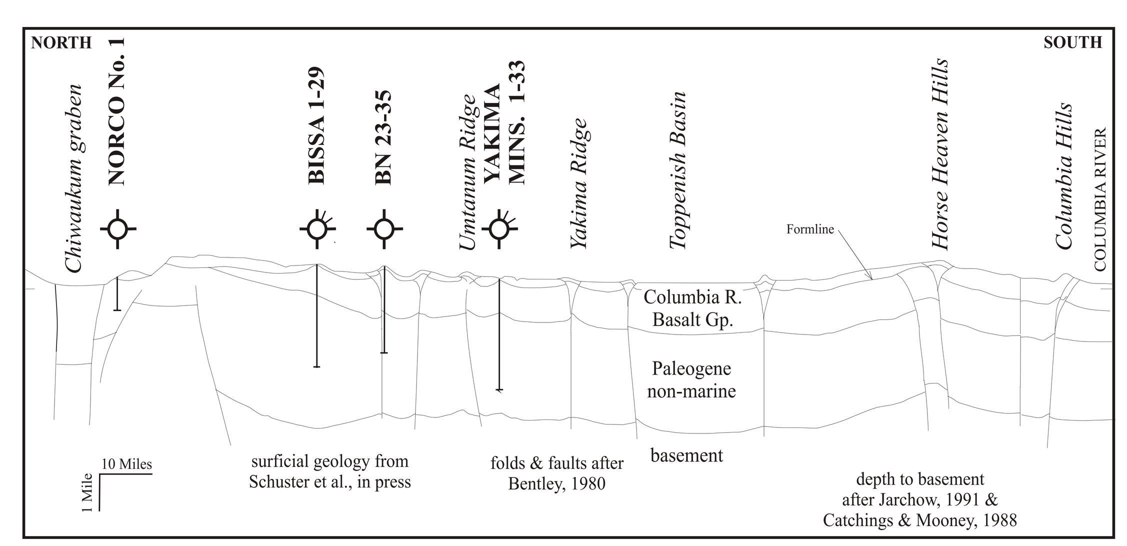

Fig. 10. Simplified structural cross section of the Columbia Basin showing probable fault configurations. Note width of Horse Heaven Hills Anticlinorium.

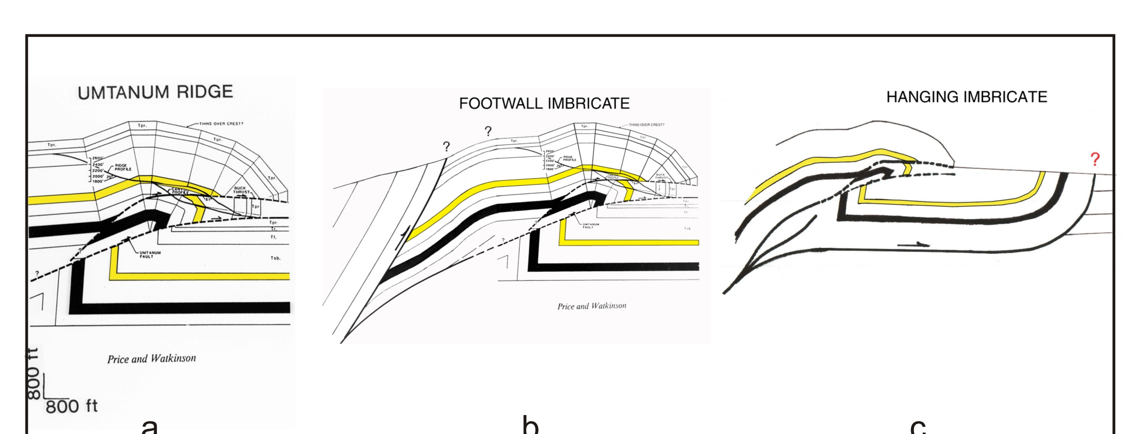

Fig. 11. Cross section (a) and models (b, c) of the Umptaneum anticline illustrating displacement v throw problems created by a decollement thrust model for the Yakima Fold Belt. If these structures result from thrusting, one would expect displacement to be much greater than throw. Therefore the absence of large displacement faults at "?" on 11b and 11c together with observed throw approximately equal to displacement (11a) shed doubt on a decollement model.

Fig. 12. South Plunge of the Horse Heaven Hills Anticline (Columbia River and Oregon in the foreground).

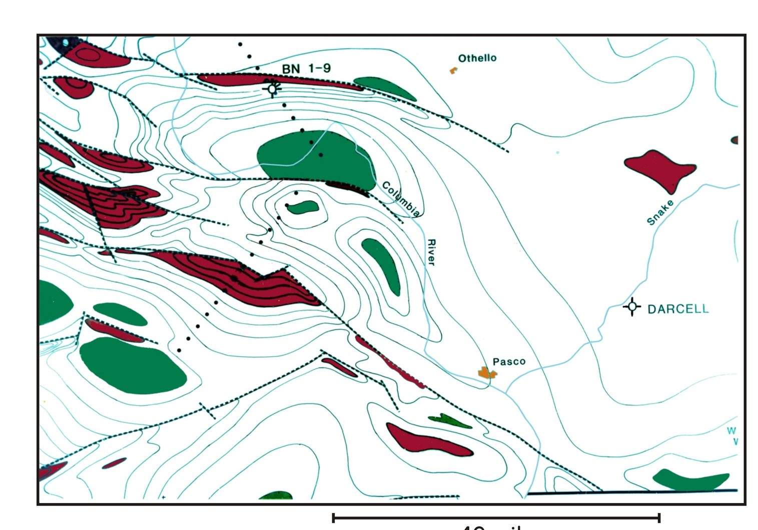

Fig. 13. Detail of structural map on the Grande Rhonde Basalt showing subsidiary domes and fault closures (red) superimposed on Yakima Fold Belt anticlinoriums. These subsidiary closures range from 5,000 to >25,000 acres.

Source and Maturation

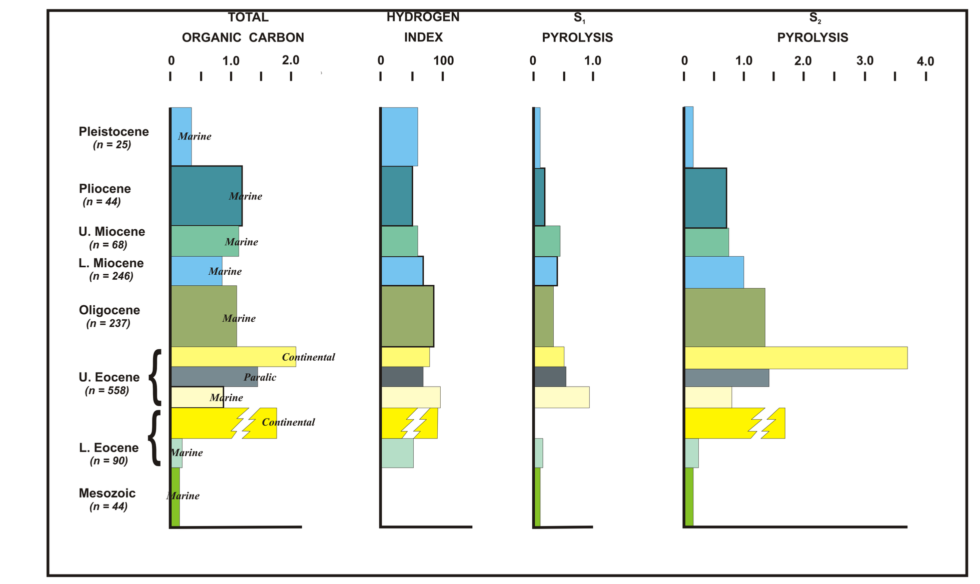

Fig. 14. Organic geochemical characteristics of selected sedimentary rocks in Washington (Lingley and Von der Dick, 1992). Data for coals are not shown except in Lower Eocene strata.

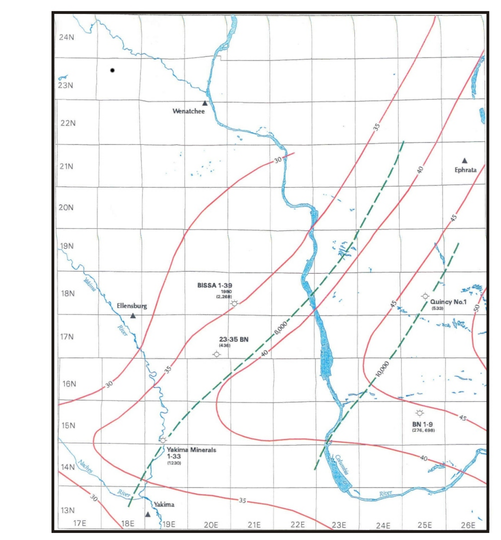

Fig. 15. Depths to Ro = 0.5 (green contours) and approximate geothermal gradients in degrees C per km (Blackwell et al., 1985).

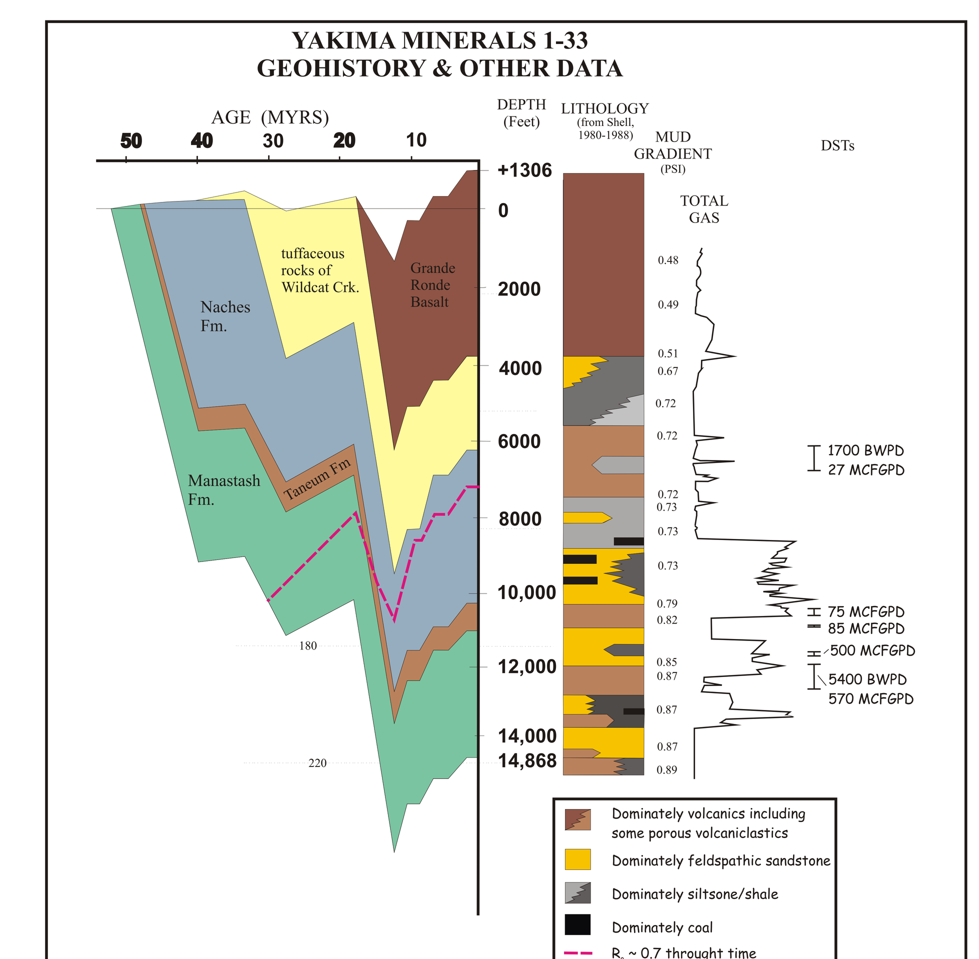

Fig. 16. Geohistory analysis of the Yakima Minerals 1-33.

The Columbia Basin was contiguous with the 30,000-ft thick Paleogene section of the Puget - Willamette Trough during the Eocene and Oligocene (Fig. 4). Where windows through younger Cascade Arc volcanics are present in the southern Cascade Range (Fig. 1), more than 10,000-ft of Eocene sand, shale, coal, and non-constructional volcanogenic rock are everywhere preserved. These source and reservoir rocks were subjected to major folding episodes during the Late Eocene, Oligocene, Middle Miocene, and Late Miocene (Fig. 16). Yakima Fold Belt anticlines developed during Middle Miocene tectonism synchronous with extrusion of copious flood basalts from fissures near the Idaho border. Lopatin analysis suggests lower Eocene coal bearing sequences reached vitrinite reflectance values of about 0.7 prior to Oligocene folding. Upper Eocene coal-bearing sequences reached this level of thermal maturity coeval with Middle Miocene uplift; hence the timing of the development of fold belt anticlines relative to gas generation and migration was probably favorable. A final phase of folding, Neogene uplift of the Southern Cascade Range, resulted in a regional east-tilted panel extending from the Cascade volcano summits eastward to the western margin of the present-day Columbia Basin near the City of Yakima. Quantifying uplift and the geometries of Yakima Fold Belt anticlines, especially west-plunge and/or the extents of north-south cross-faults may be critical to assuring closure.

Basin-Centered Gas

Interest in the basin-centered gas play has sparked the current round of exploration. The Shell BN 1-9, drilled north of the depocenter during 1985, tested large volumes of gas using a relatively small frac on a 13-ft thick sand, but at least 150-ft of additional sand was not evaluated. This well exhibits stepped pressure-depth relations as functions of thermal maturity. These profiles are typical of deep-basin centered wells (Fig. 17). The Anderville Farms No. 1 well is a down-dip offset to the BN 1-9 (Fig. 3). However, in the Yakima Minerals 1-33, large water flows, while encouraging for conventional a gas accumulation, seem to suggest that permeability is too great for a typical basin-centered play. These test results are explicable in terms of regional stratigraphic trends. Sandstones in the basin reflect two provenances:

1) Feldspathic arenite apparently derived from a Mesozoic arc located to the east in central Idaho. These feldspathic sandstones show a linear decrease in porosity with depth (Fig.6).

2) Volcanogenic sandstones derived in part from volcanic centers thought to lie northwest of the Columbia Basin. While abundant zeolites occlude pore throats in much of this sand, 5,400 BWPD tested in the Yakima Minerals 1-33 likely issues from volcanogenic sands, which probably pinch out eastward.

These data and interpretations suggest basin-centered potential may increase south and eastward in the central Columbia Basin, whereas the potential for conventional accumulations in porous volcanogenic rocks may extend to depth in the western parts of the basin.

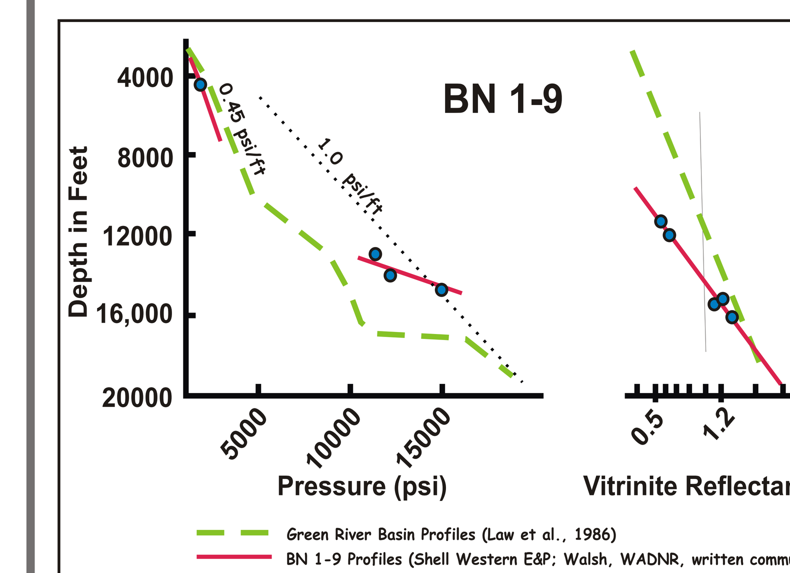

Fig. 17. Pressure-Depth and Maturity-Depth profiles for the BN 1-9 and Green River Basin wells.

Economics

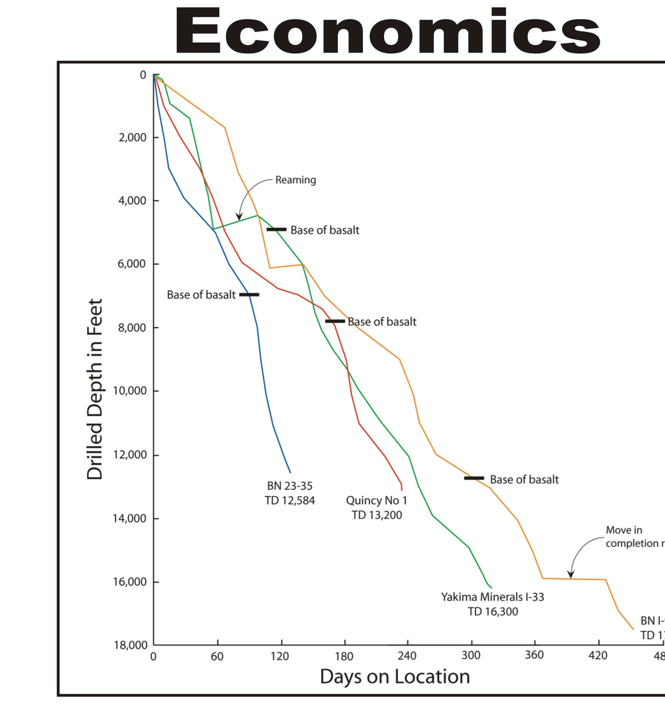

Fig. 18. Penetration rates for several Columbia Basin wildcats. The Yakima Minerals and BN 1-9 wells required excessive time on location owing to drilling problems and extensive testing. Subsequent wells have been progressively less costly because improved lost-circulation strategies in the basalt. Dryhole costs were $2.89 million for the BN 23-35 well (Meridian, 1995).

In addition to unusual drilling problems encountered while drilling thick volcanic sequences, Washington lies far from industry infrastructure. Oil and gas regulation is not sophisticated. Some state and other lands are subject to many environmental restrictions. While these may create some frustration, they are seldom unsurmountable. For example, surface discharge from CBM wells is very difficult to permit, but an operator was able to sell produced waters to a local government for municipal use. Operators should allow long periods for permitting production and pipelines and expect to produce an EIS for the initial field.

Table 2. Columbia Basin Reserve Estimates

Mean Undiscovered Technically Recoverable Gas Resources for the Columbia River Basin -- Basin Centered Gas Play Are 12.2 TCF. Reserves for the Northwestern Columbia Plateau (conventional) Gas Play Are 235 BCF (Johnson and others, 1997)

Possible Per Trap Gas-in-Place Ranges from 40 to 1,000 BCF (Lingley and Walsh, 1986).

The Geologic Potential for Technologically and Economically Recoverable Gas Reserves [from an 11,400-acre trap] is Good to Excellent. Unrisked Reserves are 197 to 475 BCF for this Trap, Offering a 23 to 93% Risked AFIT Internal Rate of Return [based on ~$2/Mmbtu gas in 1995] (Barakat and Chamberlain, 1995).

References available at website cited above.

Digital geology in part by Stephen Slaughter.