



WESTCARB Phase I Results Review

Initial Characterization of Sedimentary Basins in Washington & Oregon


Stephen D. Thomas, C.HG.
Golder Associates Inc.
sdthomas@golder.com (tel:425-883-0777)

Berkeley, CA
November 9, 2005





Objectives

- Develop database of sedimentary basins in WA & OR
 - Exclude coal-bearing formations
 - Add results to the Carbon Atlas
- Research existing information and data
 - Short timeframe
- Basin attributes:
 - Geometries (area, depth, thickness)
 - Structures (trapping details)
 - Engineering properties (porosity, permeability)
 - Geochemical information



WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP 2



Geomorphic Provinces

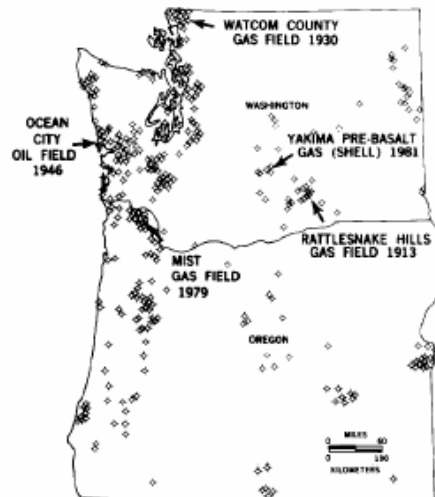


WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP 3



Information Sources

- Federal, State and Local governments
 - USGS, WA DNR, ODGAMI
- Private data
- Well databases
- Literature review
- Research & academics

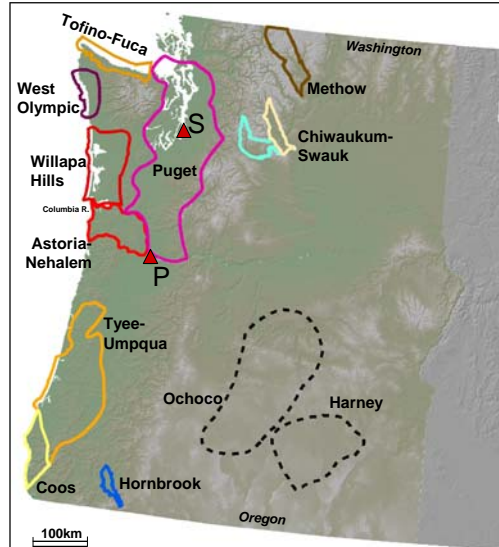


WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP 4



Sedimentary Basins in Oregon and Washington

- Coastal Ranges
- Puget Trough
- Several Interior basins
- 30+ unconsolidated basins

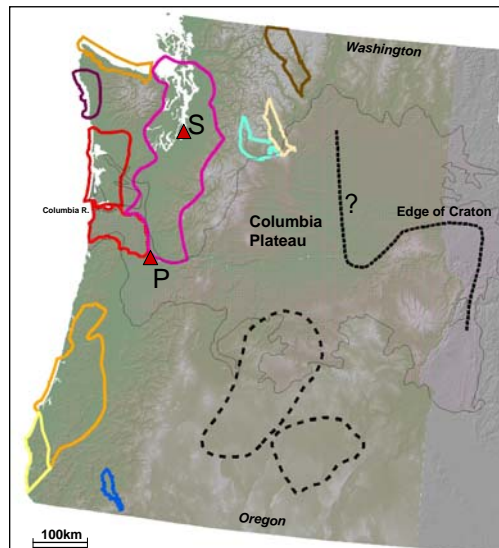


WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP 5



Sedimentary Basins in Oregon and Washington

- Coastal Ranges
- Puget Trough
- Several Interior basins
- 30+ unconsolidated basins
- Sub-Columbia Plateau

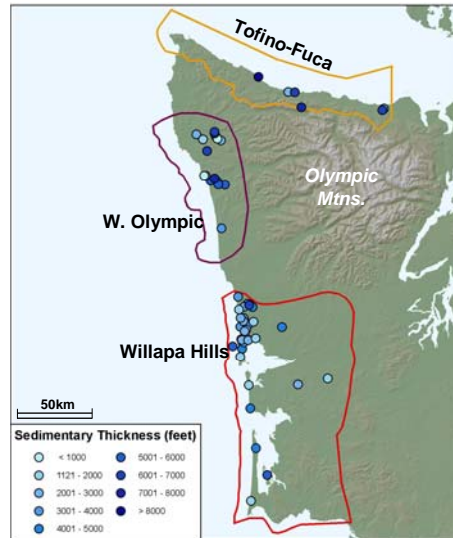


WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP 6



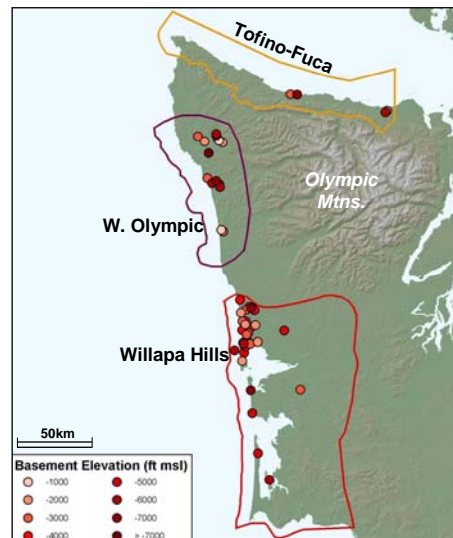
Coastal Ranges of Washington

- Tertiary forearc environment
 - Up to 20,000 ft of sedimentary sequence
 - Continental, near-shore and marine sands
 - Some massive sandstones, often interbedded with siltstones
- Basement of early Eocene ocean basalts
- Some hydrocarbon exploration (1940s)
 - but limited production



Coastal Ranges of Washington

- Tofino-Fuca Basin
 - Asymmetric W-E syncline
 - Twin River Group
 - Makah sandstone properties:
 - Porosity: 20-25%
 - Permeability: 2-7.5 darcies
 - Not structurally promising
 - A few local faults
 - Lacks obvious cap



Coastal Ranges of Washington

- W. Olympic Basin
 - Marine sedimentary sequence of more than 9,000 feet
 - 30+ hydrocarbon exploration wells
 - Most promise likely offshore
 - Hoh Assemblage
 - Some massive sandstones (Lincoln Creek Fmn.)
 - Properties
 - Porosities: 36–46%
 - Permeabilities: 102-917 md
 - Highly deformed
 - Some structural traps
 - Tectonically active



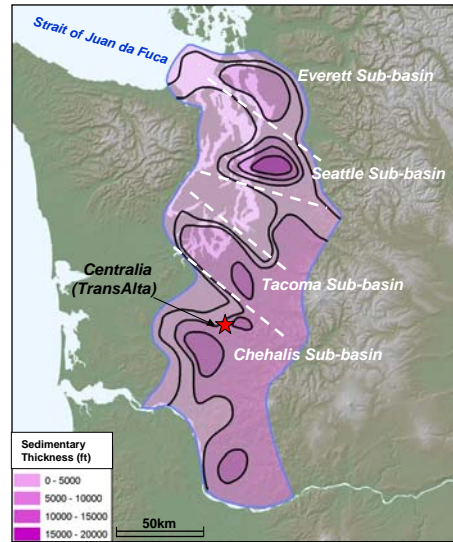
Coastal Ranges of Washington

- Willapa Hills Basin (Grays Harbor)
 - Similar stratigraphy to W. Olympic Basin
 - Up to 15,000 feet of sedimentary sequence
 - Most promising CR Basin for hydrocarbon development and production
 - Deep-water arkosic sandstones
 - Thick shales/claystones
 - Miocene compression, anticlinal traps
 - Montesano Formation properties:
 - Porosities: 6.4–32.7%
 - Permeabilities: up to 522 md



Puget Trough

- Part of Fore-arc basin
 - Tertiary tectonic activity
 - Faulted sub-basins
- Blakeley Formation
 - Thick marine sequence (sandstone, siltstone, conglomerate, shale)
- Puget Group
 - Continental sequence
 - Contains massive sandstones

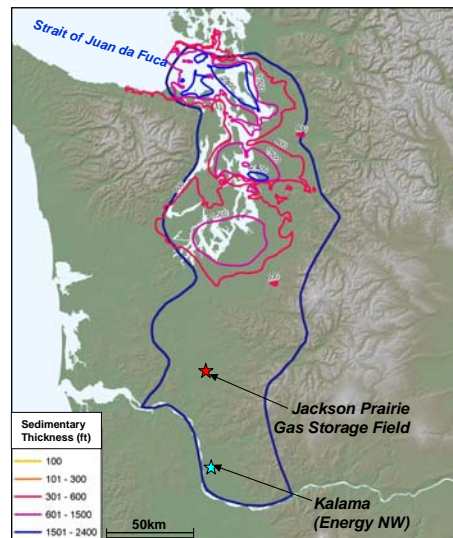


WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP 11



Puget Trough

- Affected by Quaternary glaciations - thick sediment cover
- Chehalis Sub-basin
 - 100+ exploration wells
 - Up to 15,000 feet sequence
 - Skookumchuck Fmn.
 - Porosities: 30-38%
 - Permeabilities: 135-3,000 md
 - Jackson Prairie GSF
 - 50 BCFG

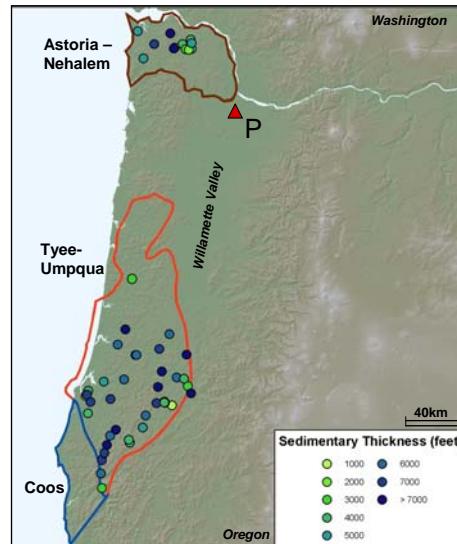


WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP 12



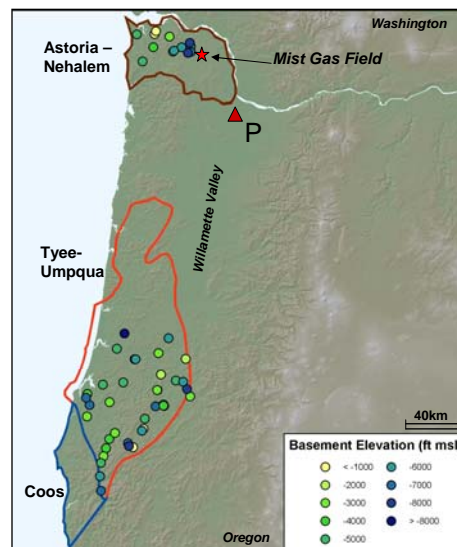
Coastal Range Basins of Oregon

- Tertiary forearc environment
- Three main basins
 - Extend beneath Willamette Lowlands
 - Very thick sedimentary units
- ODGAMI survey series very valuable
 - 80+ deep exploration wells
- Basement of ocean volcanics



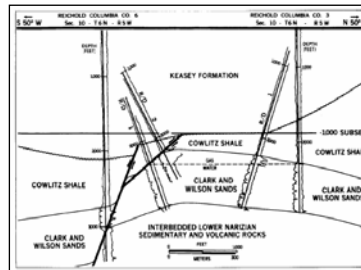
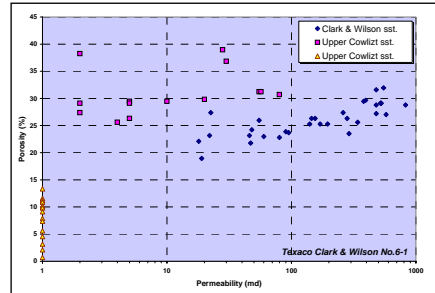
Coastal Range Basins of Oregon

- Tyee-Umpqua Basin
 - Two overlapping basins
 - Much hydrocarbon expln.
 - Massive Tyee sandstones
- Coos Basin
 - Marine sequence up to 10,000 ft thick
 - Coalcedo and Fluornoy properties:
 - Porosities: 18–43%
 - Permeabilities: 4.5–1,800 md



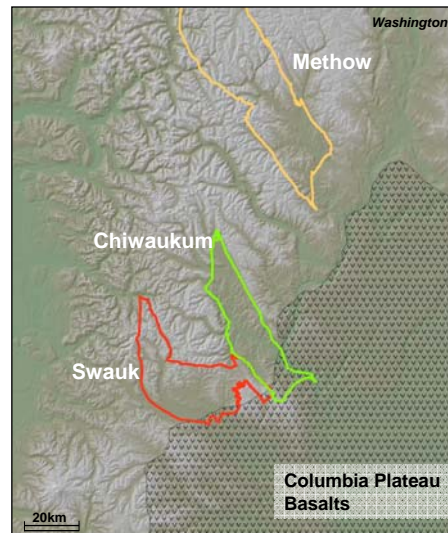
Coastal Range Basins of Oregon

- Astoria-Nehalem Basin
 - Extensively faulted/folded
 - Mist Gas Field (65 BCFG)
 - C&W Sands:
 - Porosities: up to 39%
 - Permeabilities: 1–1,400 md



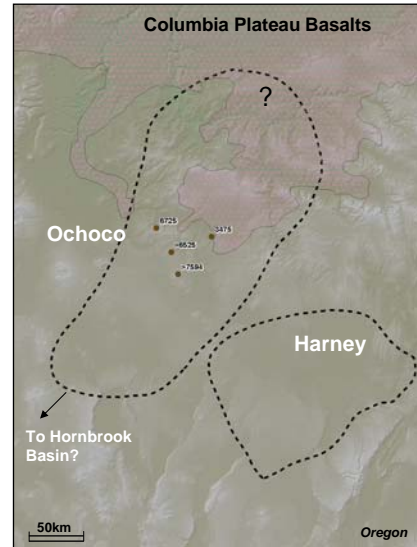
Other Interior Basins

- Graben structures
 - Likely extend beneath Basalts
- Limited depth information
- Methow Basin
 - ~13,000 feet of sedimentary sequence (Mesozoic)
 - Several massive sandstones (Winthrop)
 - Internally faulted/folded
- Chiwaukum Basin
 - ~19,000 ft of continental sedimentary sequences



Other Interior Basins

- Ochoco Basin
 - >5,000 feet of fluvio-deltaic sandstones/conglomerates
 - Overlies metasedimentary basement
- Hornbrook Basin
 - ~4,000 feet sequence
 - Hornbrook Fmn. sandstones:
 - Porosities: 6.3-18.6%
 - Permeabilities: up to 1.2 md



Summary

- Potential for storage in several Coastal Range Basins
 - Reasonably good engineering properties
 - More detailed assessment necessary
- Thick sedimentary sequences extend beneath Puget Trough
 - Well-defined attributes (Chehalis)
 - Most densely populated region
- Large potential volume beneath Sub-Columbia Plateau
 - Depth to base of basalts make it very challenging
- Unproven area and volume for several interior basins

