Wellman Field Case History

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Presentation Outline

- Locator Map and Geologic Overview
- Reservoir Properties Summary
- Primary Flood Summary
- Secondary Flood Summary
- Tertiary Flood
  - Overview of Process
  - Brief History
  - Forecasting Production
  - Well work Overview
  - Future Plans
- Summary / Conclusions
Wellman Unit Locator Map

Wellman Field is part of the Horseshoe Atoll Complex
Wellman Field Geological Summary

▲ Pinnacle Reef structure of 2100 Acres
▲ Wolfcamp / Cisco formation at a depth of approximately 9200’ - 10,000’
▲ Limestone with a 8.5% average porosity and an OOIP of 127 MMSTB
▲ Extensive exposure and erosion
  ➢ Vugular porosity is a large part of the storage and delivery system
▲ Evidence of widespread fracturing
  ➢ Fracture porosity is a small part of the storage but a large part of the delivery system
▲ Some sections of intercrystalline porosity
  ➢ Intercrystalline porosity is a small part of the storage and delivery system
▲ Two main pinnacles with vertical relief of over 800’
▲ Limited active Permian /Pennsylvanian water drive
Wellman Field Reservoir Properties Summary

- Original Oil in Place = 127 MMSTB
- Original O/W Contact = -6680' ss
- Maximum Oil Column Thickness = 824'
- Average Porosity = 8.5%
- Initial Water Saturation = 20%
- Residual Oil Saturation to Water = 35%
- Average Core Permeability = 135 md
- Initial Reservoir Pressure = 4105 psi, Oil Bubblepoint = 1250 psi
- Initial Reservoir Temperature = 151°F
- Initial Oil Gravity = 43.5 API, Water Specific Gravity = 1.13
- Initial Oil Formation Volume Factor = 1.3, Initial Solution Gas Oil Ratio = 405 Scf/STB
- Initial Oil Viscosity = 0.43 cp, MMP (100% CO2) = 1600 +/- 50 psi
- Vertical Core Flood Oil Saturation to CO2 < 10%
Primary production started in 1950 and unitized in 1978.

- Reservoir pressure initially dropped from 4105 to 3000 psi until the 3000 B/D Oil allowable was established.
- The allowable lowered to 1500 B/D and pressure slowly increased to 3100 psi.
- The allowable was increased to 7500 B/D in 1966, and reservoir pressure dropped below the 1250 psi bubblepoint by 1976.
- Field producing GOR remained fairly low.
- High vertical permeability likely caused a secondary gas cap to form.
- Recovery during this period was 33% of OOIP.

6000 BOPD Initial Peak Rate

3000 then 1500 BOPD Allowable

Allowable Lifted
- Started makeup water injection 6/1979 with 4 wells below OWC
- Pressure increased from 1050 to 1600 psi by 1983 (end of Waterflood Only Period)
- Field remained at top allowable of 9300 BOPD for most of this period
- Bottom water flood moved the Oil Water contact from -6680’ to -6300’ss
- Incremental recovery during this period was 11% of OOIP (44% P+S)
- Calculated volumetric sweep efficiency of 93%
Vertical CO2 flood where CO2 is injected into the top of the structure and mobilizes waterflood residual oil from the rock as the CO2 contact moves down through the formation creating an oil-column between the CO2 (above) and water (below)

Producing wells are completed near the oil-column and then recompleted deeper over time, as the CO2-oil contact is moved deeper

Oil production is expected to continue to grow as the oil column is thickened and additional temporarily abandoned wells are returned to production

Wellman’s performance and geology has been well-documented by the EOR industry and is considered one of the best performing CO2 floods on record

― SPE papers 11129, 22898 and 48948
Wellman CO2 Production History

Union Texas → Mobil ← Wiser → Petrosource/Trinity

Peak oil from historical, bottom up waterflood
Start CO2 purchase
Resume CO2 Purchase
Sell CO2
End CO2 purchases

Start CO2 purchase

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Wellman Recent CO2 Production History

[Graph showing production rates over time for various parameters such as oil rate, HC GOR, recovery % OOIP, daily water and CO2 rates, produced total gas, CO2 purchase, produced water, water injection, CO2 injection, CO2 sales, oil production, and oil recovery.]
Nearing maximum column thickness

WELLMAN UNIT - Estimated Contact History and Forecast

- Gas/Oil Contact EOM (feet)
- Oil/Water Contact EOM (feet)
- Original O/W Contact
- Oil Column Interval EOM (feet)

Historical Data
Deepest CO2 Penetration ~ -6360' in 2002
CO2 Blow down
Initial CO2 Injection
CO2 Purchases
Current OWC -6510'
Original O/W Contact - 6680'
Brief Wellman CO2 Teritiary Flood History

▲ Started in 1983 by Union Texas with 3 Crestal Injectors

- CO2 Purchase rates ranged 4 - 15 MMcf/D, averaging 8.2 MMcf/D
- Recycled CO2 rates varied from 3 - 27 MMcf/D, averaging 18 MMcf/D
- Oil production dropped during this period from 8500 to 2000 BOPD, averaging 4440 BOPD
- Active water injection in the reef drove the O/W up from -6300’ to -6150’ ss
- Sporadic and ineffective completions limited ability to produce the oil column
- Oil column during this period shrank from 400’ to 20’

▲ Operated by Mobil from 9/1991 to 10/1993

- CO2 purchase rates ranged 15 - 18 MMcf/D, averaging 16 MMcf/D
- Recycled CO2 rates varied from 23 -27 MMcf/D, averaging 25 MMcf/D
- Oil production dropped during this period from 2000 to 1200 BOPD, averaging 1480 BOPD
- Water Re-injection continued and the O/W moved down from -6150’ to -6250’ ss
- Little to no well work was done to recomplete producers into the oil column
- Oil column during this period grew slightly from 20’ to 25’
Operated by Wiser Oil Co from 10/1993 until 3/2005

- CO2 Purchase rates ranged 5 - 15 MMCFPD until 10/2001 when purchase was stopped, 6.8 MMcf/D average
- CO2 Production rates ranged 2 - 21 MMCFPD during CO2 blown down from 5/2003 to 3/2005, 3.4 MMcf/D average
- Oil production dropped during this period varied from 50 to 2200 BOPD, averaging 1100 BOPD
- The O/W contact moved from -6300' to -6380’ ss until CO2 blowdown, where it ended at -6314’
- Wiser was active working over many wells during this period
- Oil column during this period shrank from 25’ to 0’

Operated by Petrosource / Sandridge / Trinity from 3/2005 until Present

- CO2 blowdown was immediately stopped and CO2 purchases resumed
- Oil production increased during this period from 17 to 2300 BOPD, averaging 1100 BOPD
- The O/W contact lowered from -6380’ to -6510’ ss with higher CO2 purchase volumes and disposal of all produced water
- Over 16 producers have been returned to production
- Over 50 Plugdowns have been successfully executed since 2006
- Oil Column during this period has grown from 0’ to 45’
  - This thicker oil column has allowed for much higher per well rates
  - The “average” oil column producer at Wellman now makes over 200 BOPD
Correlations used as model inputs have proven very reliable

Tank Model – Primary Inputs
- Producing well count
- CO2 purchases
- Water withdrawal
- Waterflood Residual Oil Sat, Sorw = Srw = 0.35
- CO2 Flood Residual Oil Sat, Sorc = 0.105
- Reservoir Pressure current 2200 psi
- Pore volume vs Depth

Tank Model – Primary Calculations
- CO2 contact depth
- Water contact depth
- Oil column thickness
- Oil column correlations used
  - BOE/d per well
  - Total GOR
  - BW/d per well
- Oil, water and gas production forecast, SPE 22898
  - \( V_o = (S_{orw} - S_{orc}) I_{CO2} B_{CO2} / (B_o \Delta S) \)
  - \( \Delta S = (1 - S_{rw} - S_{orc}) \)
Highly accurate tank model relative to historic results

Actual performance has confirmed the tank model accurately forecasts future production rates.
Plug downs are repeated until the oil column reaches the base of the transition zone -6720’ss
Based on the Previous Tank Model estimates and current logged CO2 contacts, producers are plugged down every 18 -24 mos

- Old perforations are isolated in the plug down procedure using packers and an isolation string

Successfully returned 16 producers, 3 deep disposal and 1 CO2 injector to active service

- No new drills needed to date
- 20 of 21 successful returns to production

Ongoing work

- 9 – 10 plug downs expected annually until the contacts reach the original OWC
- Contact currently moves about 2 ft/month
Wellman Unit Operations Overview

Wellman Central Tank Battery

- In service – April 2011
- Design Capacity – 4,000 BOPD | 40,000 BWPD | 50 MMcf/d
Compress expansion complete by March 2014
Return all required Wells to Production / Injection by December 2015
NGL Recovery Plant complete by January 2015
Wellman Unit Future Plans, Compression Expansion

Recycle Compression

- Current Capacity of 45 MMcf/d
- Expanding to 50 MMcf/d by March 2014
Most Wellman well work substantially completed

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- No new drills needed to date
- 20 of 21 successful returns to production

19 of 28 total wells planned for reactivation completed to date

9 additional wells are scheduled for return to production to complete project development (4) in 2013, (3) in 2014, (2) in 2015
Finalizing the evaluation of construction and design options for the installation of a 50 MMcf/d inlet capacity NGL plant to process rich Wellman NGL stream currently being re-injected

- Add on to our existing recycle compression scheme, taking the gas stream from the 2nd stage discharge and returning to the 3rd stage suction
- Designed to maximize the recovery of the C4+ and provide C5+ for crude blending for sale into the crude line.
- A truck rack with NGL bullets will be constructed
- NGL sales line is also being evaluated
- 3rd party owned and operated with fee taken as a percentage of the production
- Expected max NGL rate of over 1000 B/D
The Wolfcamp Reservoir in Wellman has performed in almost a tank like manner under Water and CO2 flooding

A world class reservoir that will recover almost 80% of OOIP

Almost all capital investment has been made reach over 3000 BOPD and 1000 Bbl NGL / Day in 2015

- The field will have almost new facilities
- Almost all required producing wells have been returned to production
- Trinity has a good track record of plugging down to stay in the oil column
Thanks to the Following Trinity Team Members for making this possible

- Trinity Management Team for Permission to share the story
- Greg West and John Milam – Architects of the current flood strategy
- Jerry Metcalf and his Field Team – Amazing track record in a difficult environment
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- Bill Harryman – Senior Engineering Technician