

CO₂ Geologic Storage Assessment: A Review with Focus on Appalachia

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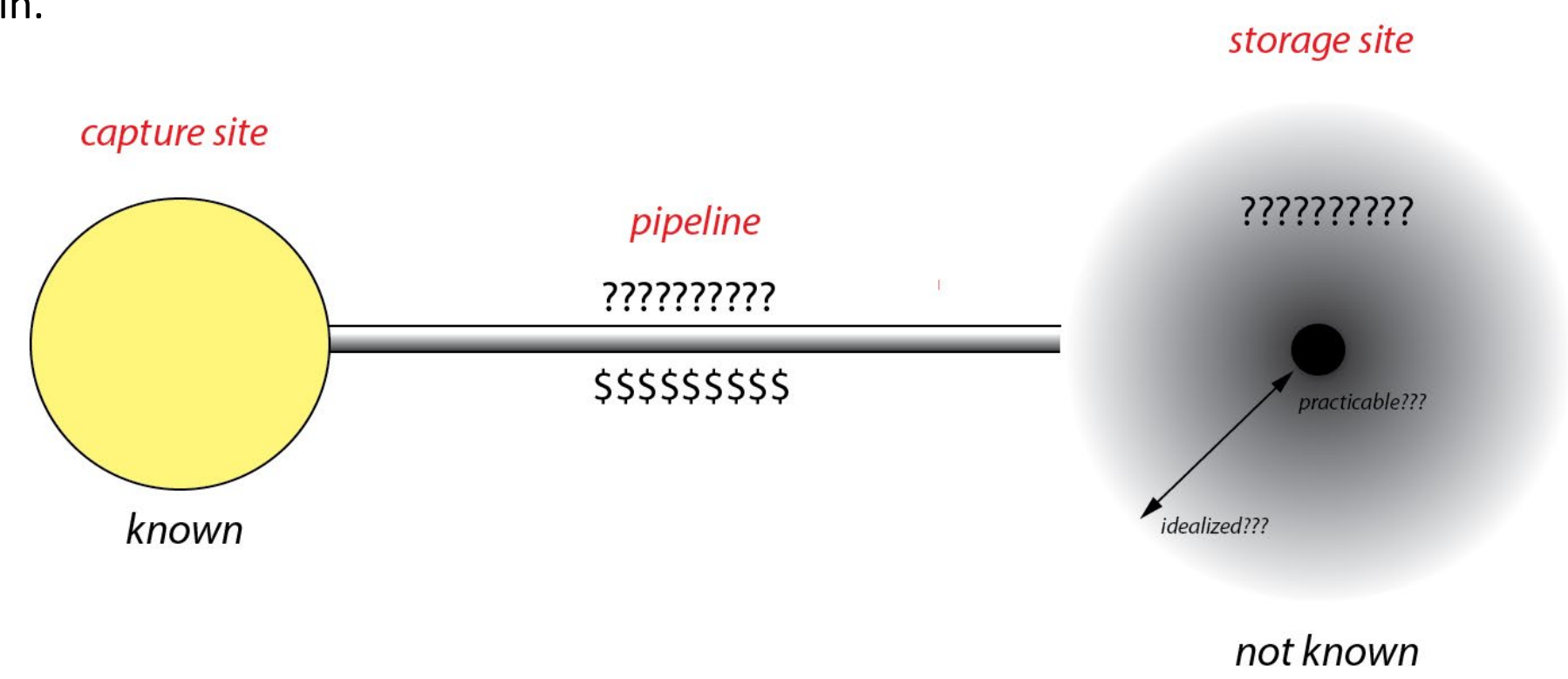
Research & Innovation Center



OBJECTIVE/RATIONALE

The Department of Energy is rapidly advancing toward investment in large-scale infrastructure to manage the permanent sequestration of CO₂ in subsurface reservoirs. To be effective, these investments must be informed by reliable assessments of subsurface storage potential at national, regional, and site-specific scales.

The objectives of this study are to 1) assess the current state of publicly-available geologic characterizations, initially for the Appalachian basin, as summarized in the most recent NATCARB Carbon Storage Atlas and 2) to provide initial information on potentially under-assessed reservoirs in the basin.



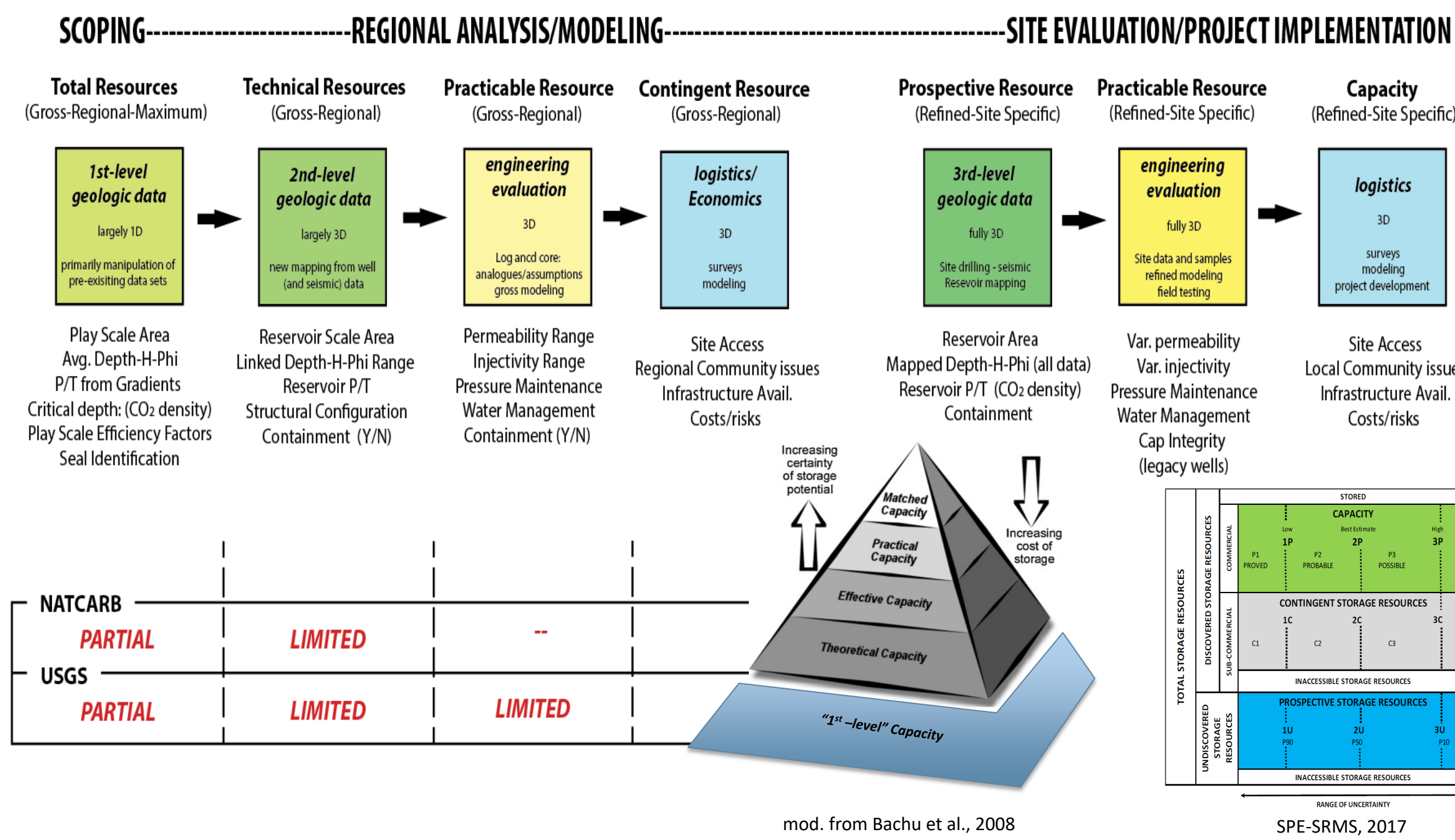
Cartoon depiction of the current state of understanding of carbon storage source volumes (left) and available subsurface sinks (right). At present, storage site volumes are very poorly constrained.

PURPOSES FOR GEOLOGIC CHARACTERIZATION

- 1) National Scoping studies – can suffice with “1st level” geological characterization.
- 2) Regional modeling of storage volumes – requires “2nd-level” geologic characterization.
- 3) Assessments related to specific storage projects – requires 3rd-level geologic characterization.

PROGRESSIVE LEVELS OF GEOLOGIC CHARACTERIZATION

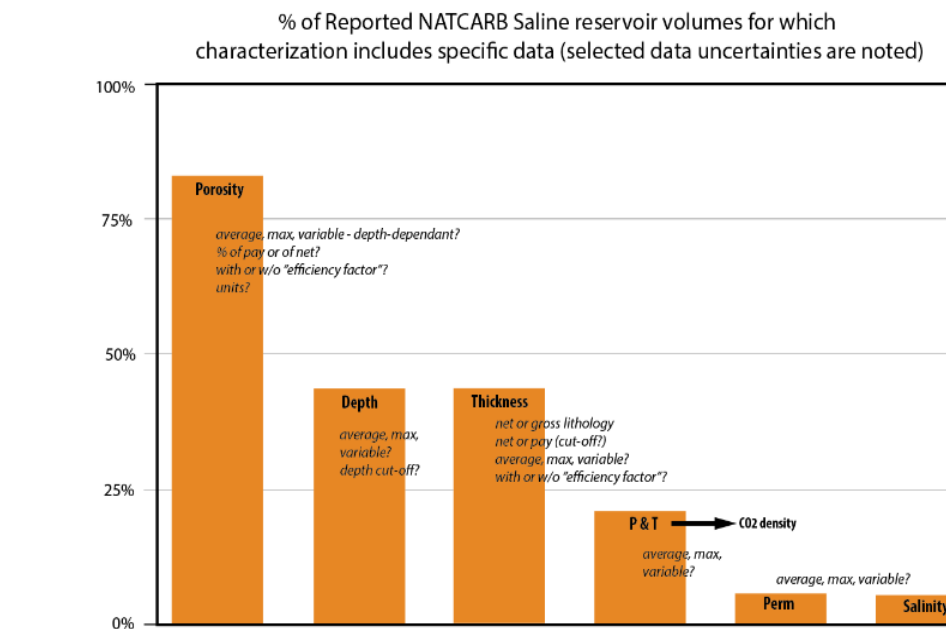
1st Level: Regional/play-scale assessments. The lack of well data for deep saline aquifers commonly results in reliance on assumptions and analogues for estimation of key reservoir parameters. As a result, geologic characterizations of storage potentials are commonly highly generalized regional/play-scale depictions that do not capture reservoir variability. Analyses built upon such data can support general national-scale scoping but are likely deficient for regional and site-specific analyses.



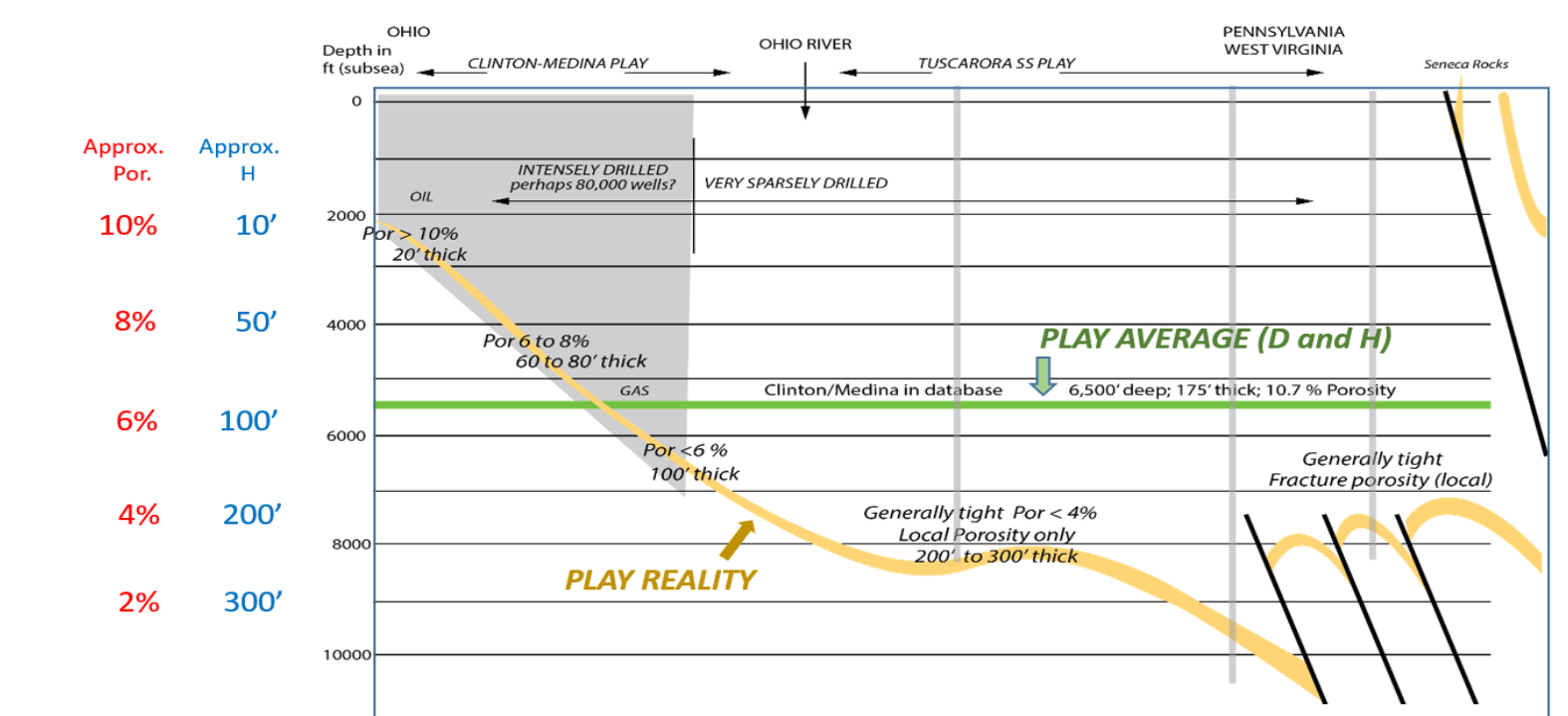
2nd-Level: Reservoir-scale geologic interpretation capturing spatial distribution and variation in depth, porosity, pressure, temperature and unit thickness as input to estimate potential capacities for regional-scale analysis and modeling.

3rd-Level: Site-specific comprehensive site (“pool”) geologic characterization using all available geologic and petrophysical data, coupled with site-specific and full 3D engineering/numerical simulation, to deliver specific project locations and capacity estimates.

2nd and 3rd-level data are commonly not available for analyses of deep saline aquifers, which would likely require high-risk, high-cost exploratory drilling and sampling to acquire needed data. While depleted reservoirs provide the necessary data, they generally do not offer the scale of storage capacity typically envisioned for saline systems.



Coverage in NATCARB v15 of various key parameters for the full dataset. Ex., 80% of reported mean storage volume has an associated porosity value. Note: Mt. Simon play appears to not contain porosity information. Over half the storage volume lacks a depth or thickness estimate.



1st level geologic characterizations are commonly expressed as single-play averages for key properties that are assigned to the full reservoir area. As an example, the above indicates the implications of such characterization for the case of the “Clinton-Medina” sandstones. The vast majority of reservoir volume occurs in units of significantly less porosity and greater depth than captured in the reservoir data.

NATCARB APPALACHIAN STORAGE CHARACTERIZATION

SALINE RESERVOIRS: Assigned significant storage potentials which are typically concentrated in the deepest, most data-poor locations of the selected plays (example: Rose Run formation).

	MIRCSZ	TOTAL MIRCSZ Phase I	TECHNICAL USGS (2013)	NATCARB V15	“PRACTICABLE” Tetzlaff et al.
Basal Sands (Conasauga)	24,873 mi ²	4.26 gt	—	—	—
Basal Sands (Potsdam)	13,999 mi ²	1.71 gt	0.52 gt	—	—
Basal Sands (Rome Trough)	18,365 mi ²	1.23 gt	6.00 gt	0.31 gt	0.364 gt
Rose Run Sandstone	74,655 mi ²	49.27 gt	15.29 gt	—	—
Clinton-Medina	64,469 mi ²	70.53 gt	12.00 gt	10.02 gt	0.739 gt
Lockport Dolomite	68,257 mi ²	—	1.60 gt	11.31 gt	0.119 gt
Bass Islands	59,063 mi ²	—	—	3.89 gt	—
Oriskany Sandstone	51,010 mi ²	19.42 gt*	0.74 gt	1.82 gt	0.056 gt

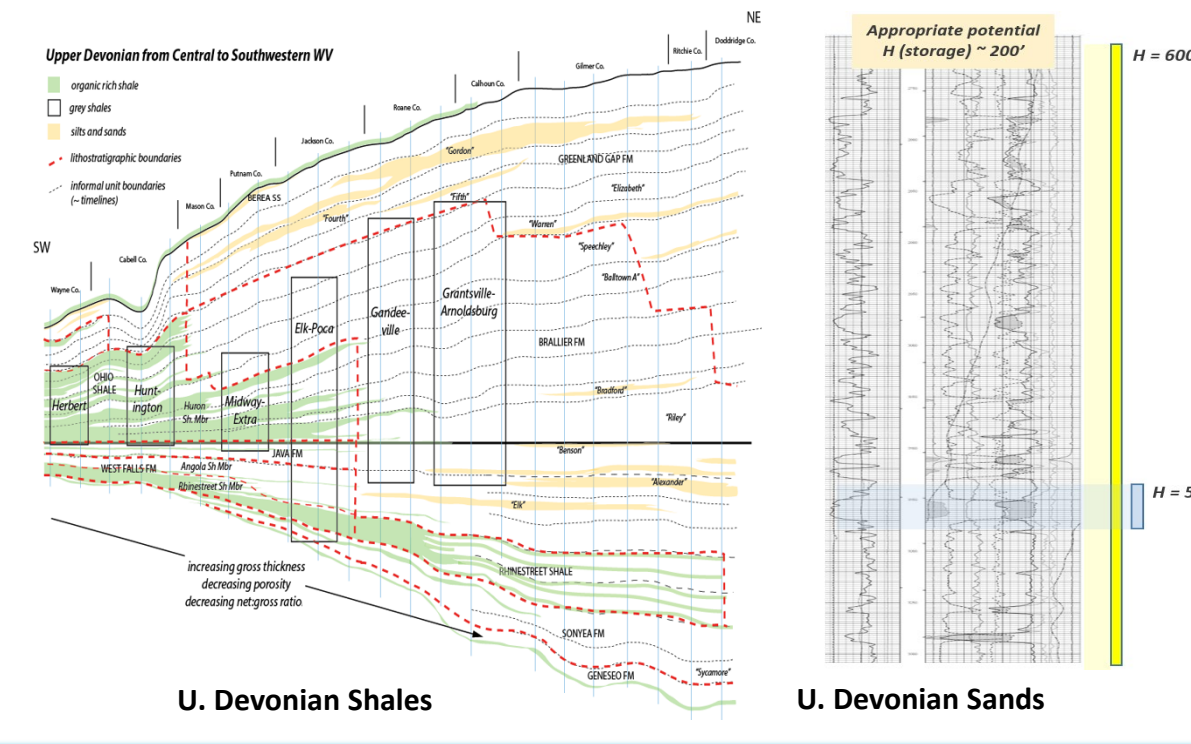
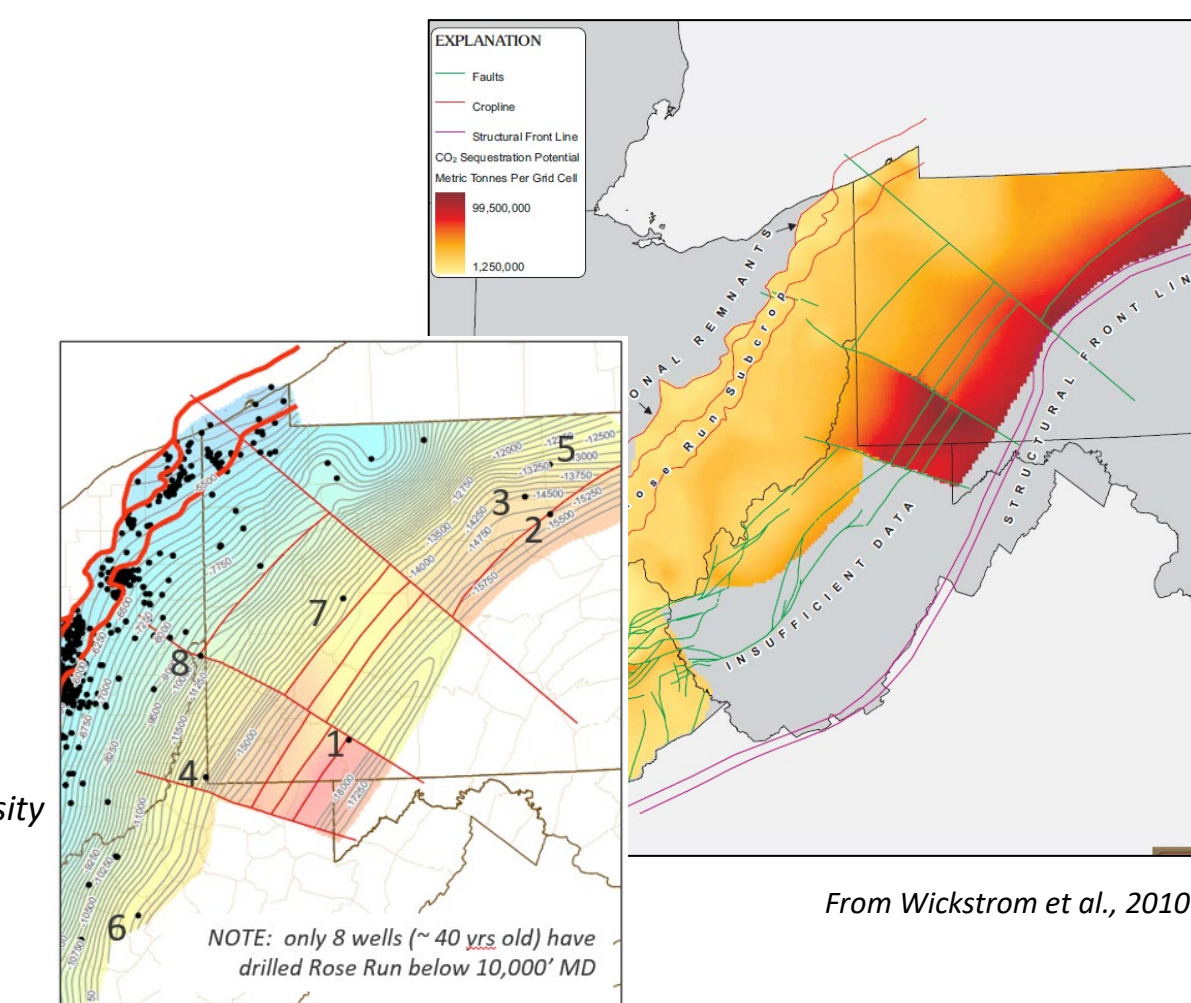
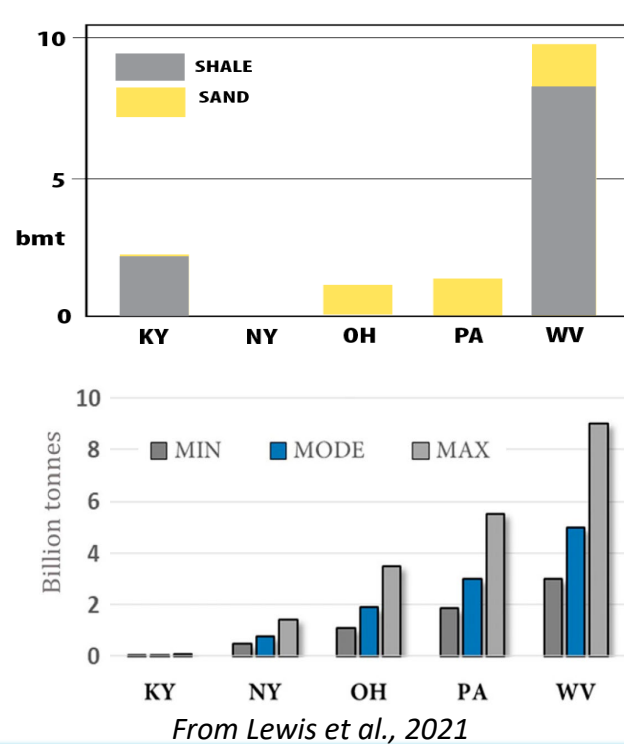
NOTE: Clinton-Medina, Oriskany, and Rose Run commonly all gas bearing in areas of elevated reservoir quality. Conversion to saline upon depletion will depend on reservoir drive mechanism (often pressure-depletion).

OIL AND GAS RESERVOIRS

- NATCARB Appalachian volumes remain dominated by U Devonian shales. Likely overstated due to optimistic pressure, pay, and porosity -- particularly in “grey shale” areas and currently under revision.
- Reservoir volumes in shallow, highly-developed, sandstones (Devonian-Mississippian) might be locally understated due to targeted “pay” in recent wells?

TYPICAL DEEP SALINE RESERVOIR

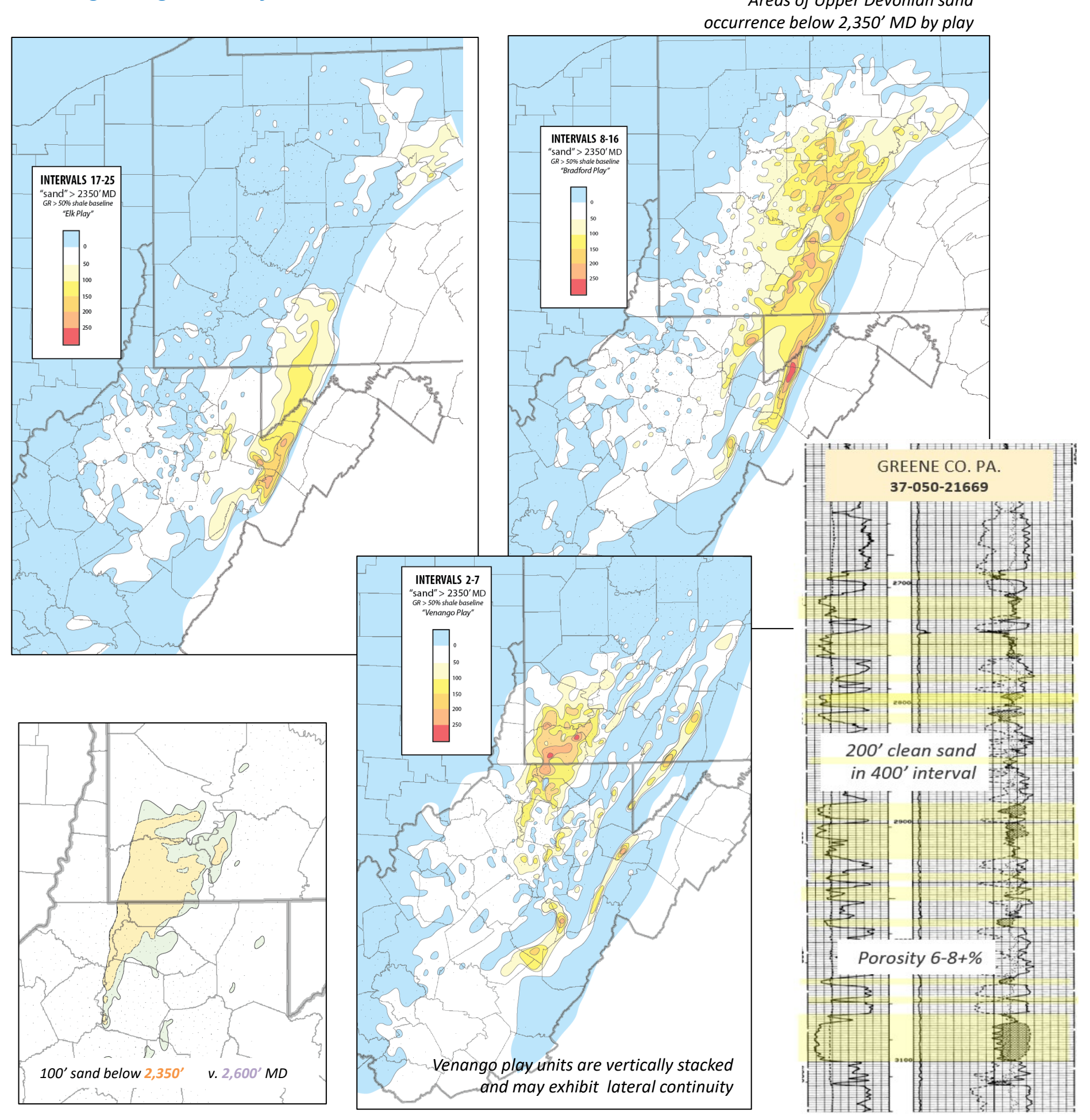
- Huge area: >70,000 mi²
- Limited/unrepresentative data
- Very deep: complex drilling
- No P/T data
- Substantial heterogeneity – low porosity
- Permeability unknown (very low)
- Close to crystalline basement



NEW DATA COLLECTION: UPPER DEVONIAN SANDSTONES

Devonian Oriskany and Silurian Clinton-Medina are locally depleted O&G reservoirs that have been the focus of significant study regarding storage potential. Select younger Appalachian sandstone reservoirs have been considered primarily for CO₂ EOR/EGR potential. Most U. Devonian sandstones are marginally tight and many produce via pressure depletion. The units are highly lenticular. Some are locally used for gas storage where reservoir quality is high. Numerous legacy well penetrations complicate seal issues. All are far above crystalline basement.

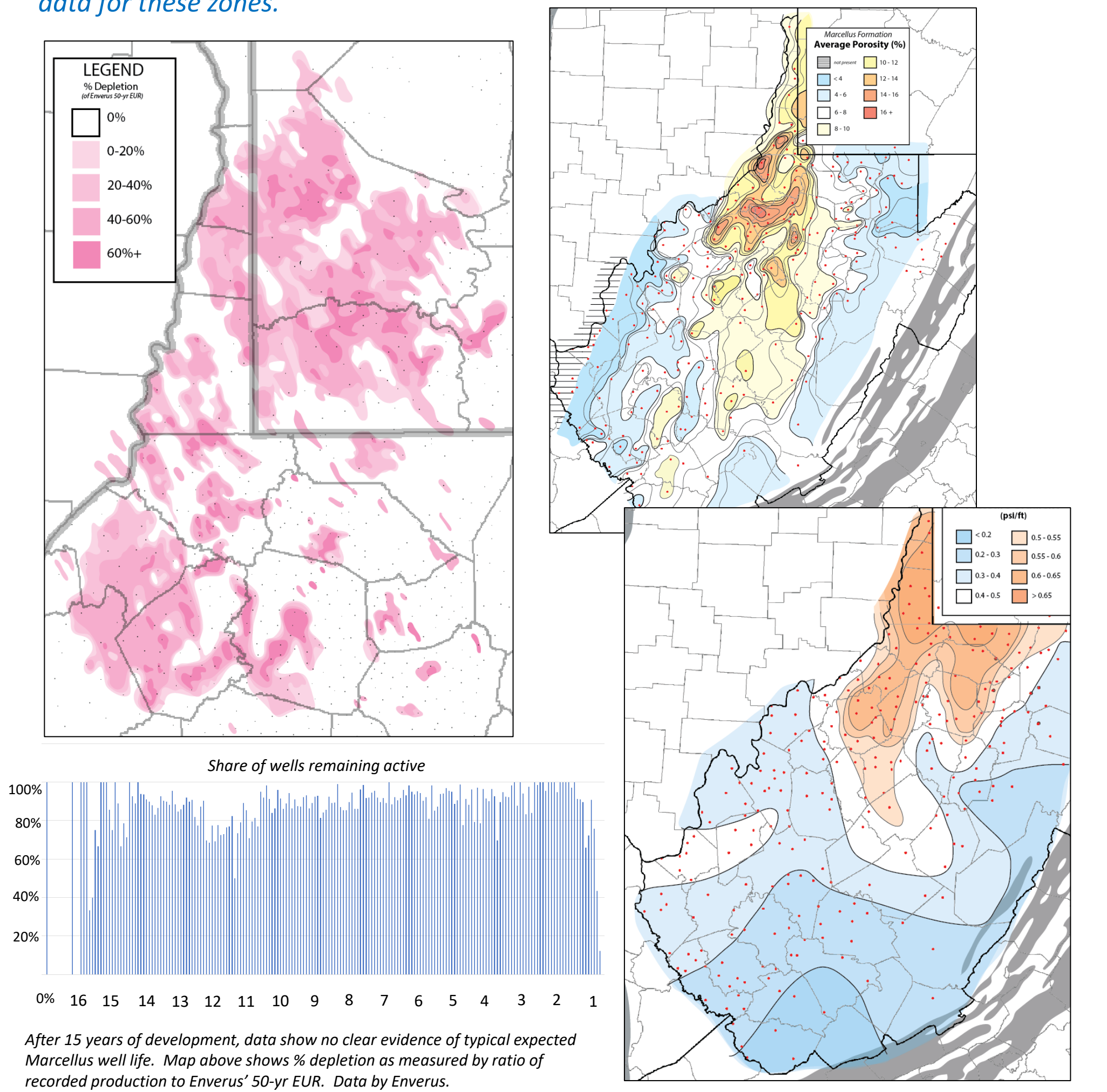
New mapping shows large areas where depleted sands occur at carbon-storage-relevant depths. Detailed geologic analyses would be needed to determine 2nd and 3rd level geologic data for these zones.



NEW DATA COLLECTION: OVERPRESSURED SHALES

Development of the deeper overpressured shales (Marcellus, Burket, Utica) had not yet begun when the initial partnership studies were conducted and are not presently included in NATCARB databases. Their overpressured state, coupled with the enhanced adsorption and potential increase in reservoir quality associated with pervasive stimulation, suggest that these shales may (?) be targets for sequestration once large continuous areas have been fully depleted.

New mapping shows large areas where Marcellus shale depletion is advancing. Detailed geologic analyses would be needed to determine 2nd and 3rd level geologic data for these zones.



IMPLICATIONS

- Existing databases are generally not suitable for supporting site selection or assessment of storage capacities.
- New data collection is needed -- data-mining/manipulation are likely not sufficient to advance characterizations to levels needed to support modeling.
- Current Appalachian saline “Total” reservoir volumes (current candidates) are likely overstated. Data to constrain risks and uncertainty for deep and saline units is lacking and would be extremely expensive to get.
- Additional deep saline targets are under investigation and may yet get defined.
- Depleted or shallow sandstones may be under-assessed and are known from 100,000s of wells. Potential targets will be abundant and vertically stacked, but individually very small and heterogeneous.
- Unassessed overpressured shales may be future targets: timeframe for widespread depletion is uncertain.

ABUNDANT DATA!

