

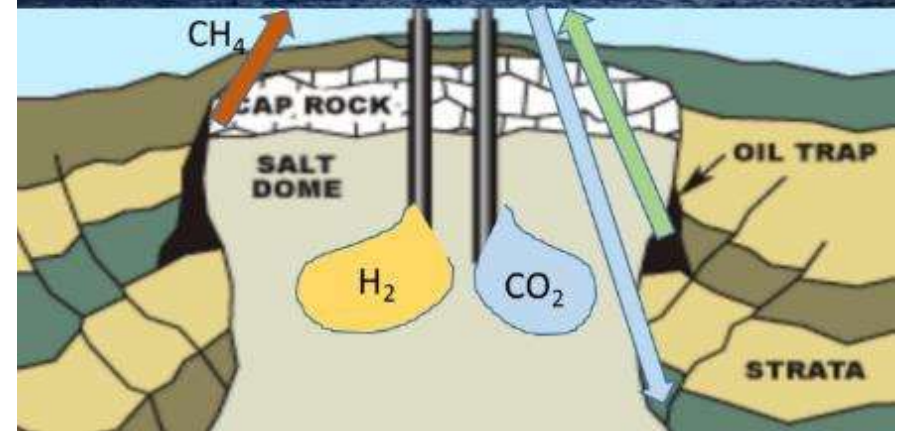
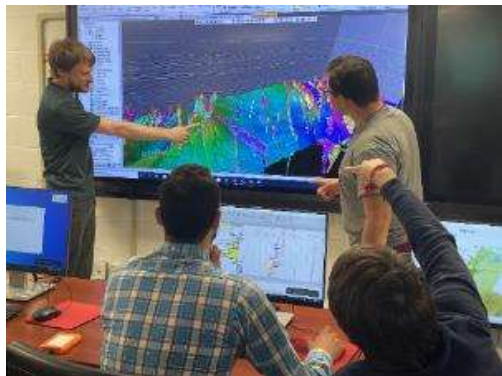
Hydrogen discovery & storage: A new era for a classical gas

Robert R. Stewart

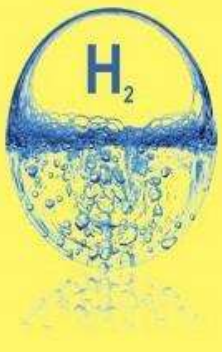
(with contributions from D. Pelemo-Daniels, A. Babalola, B. Nwafor, M. Yella, M. Myers, and J. Abdolrazzagh)

Allied Geophysical Lab
Earth & Atmospheric Sciences
University of Houston

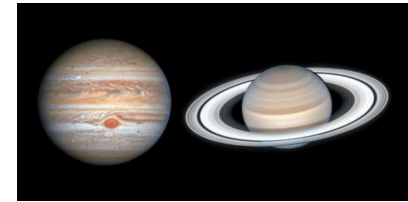
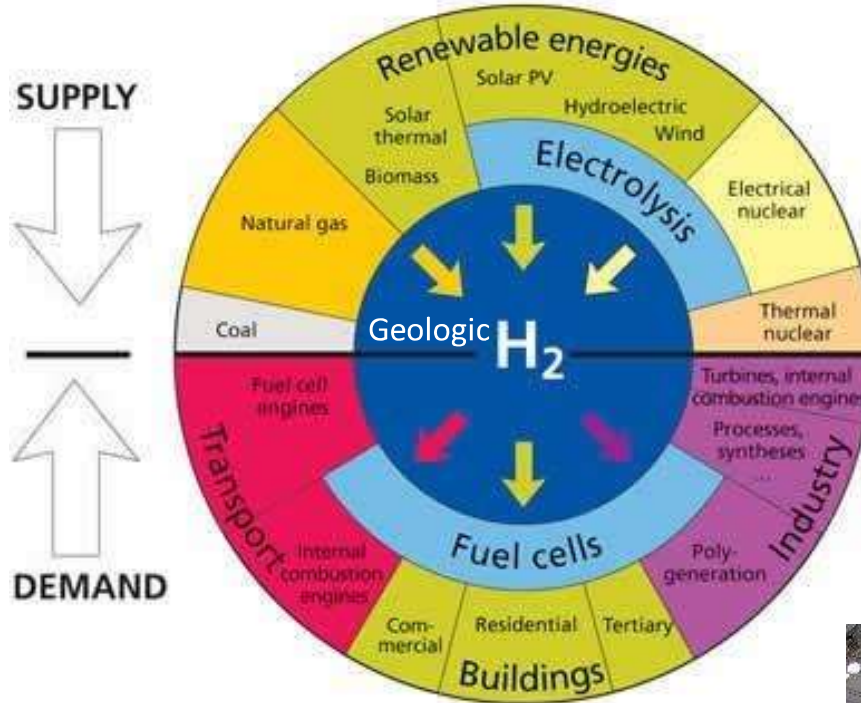
April 17th, 2024



Hydrogen – properties and uses



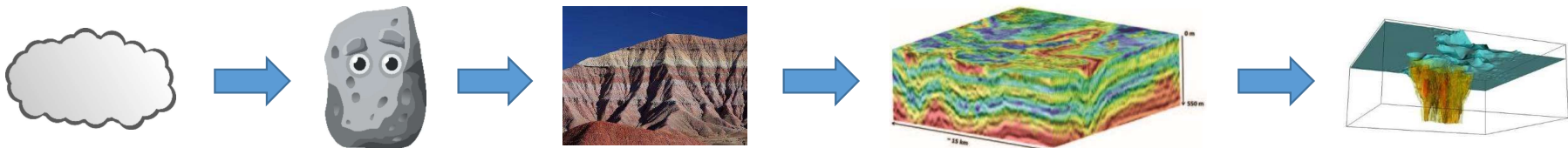
Symbol: H
Atomic mass: 1.00784 u
Atomic number: 1
Electron configuration: 1s¹
Discovered: 1766
Electrons per shell: 1
Discoverer: Henry Cavendish



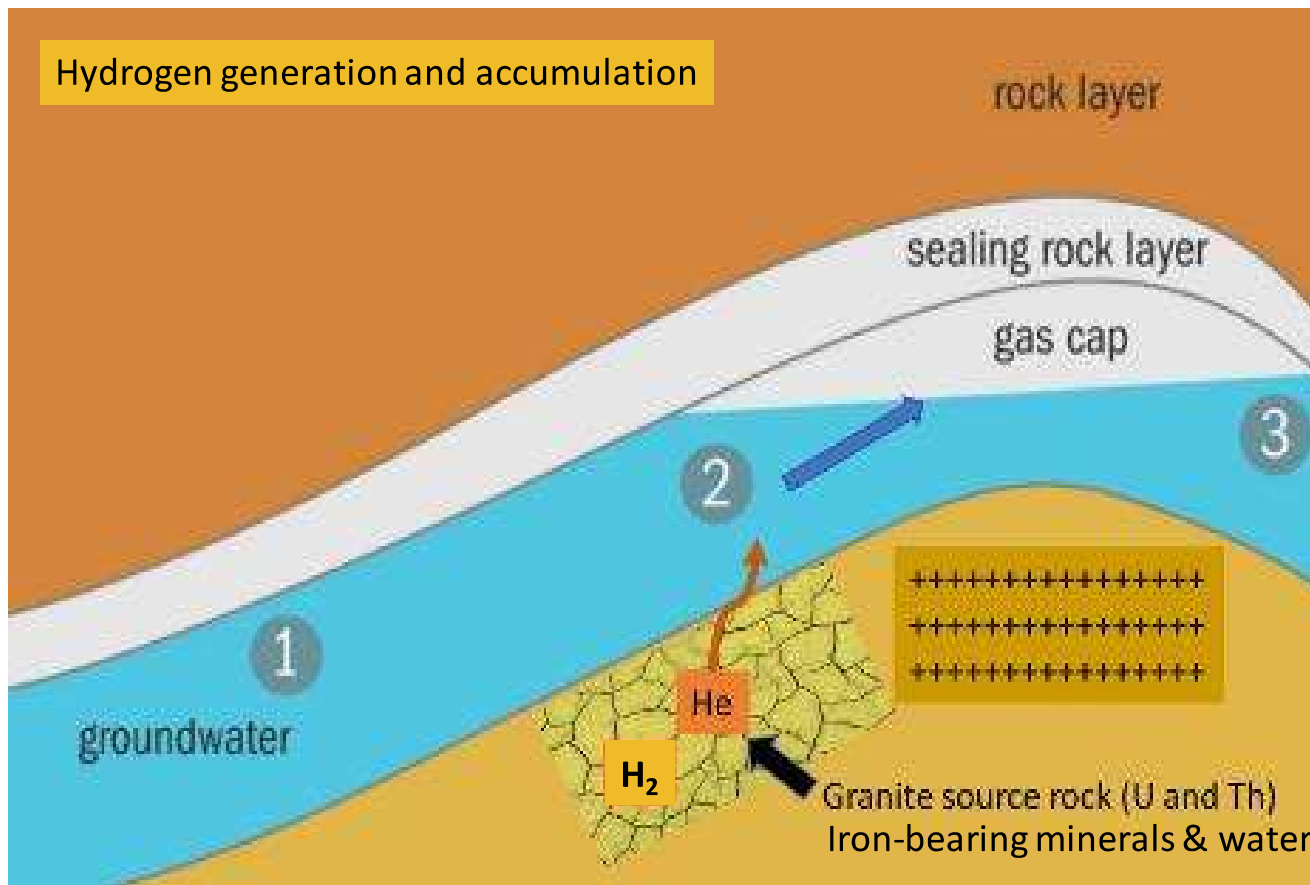
BUSINESS // ENERGY
Houston selected as one of 7 U.S. hydrogen hubs, opening up \$1.2 billion in federal funding
 By James Osborne, Washington Bureau
 Updated Oct 15, 2023 12:52 p.m.

Geologic (natural) hydrogen

- Why are we interested? *Chemicals, electricity, heat, & transportation*
- Determine gas (H_2 , He , CH_4 , CO_2 , N_2) properties
- Understand how gases affect rock properties
- Find gas reservoirs using geophysical techniques
- Measure gas movement through rocks



We are quite familiar with many parts of this system ...

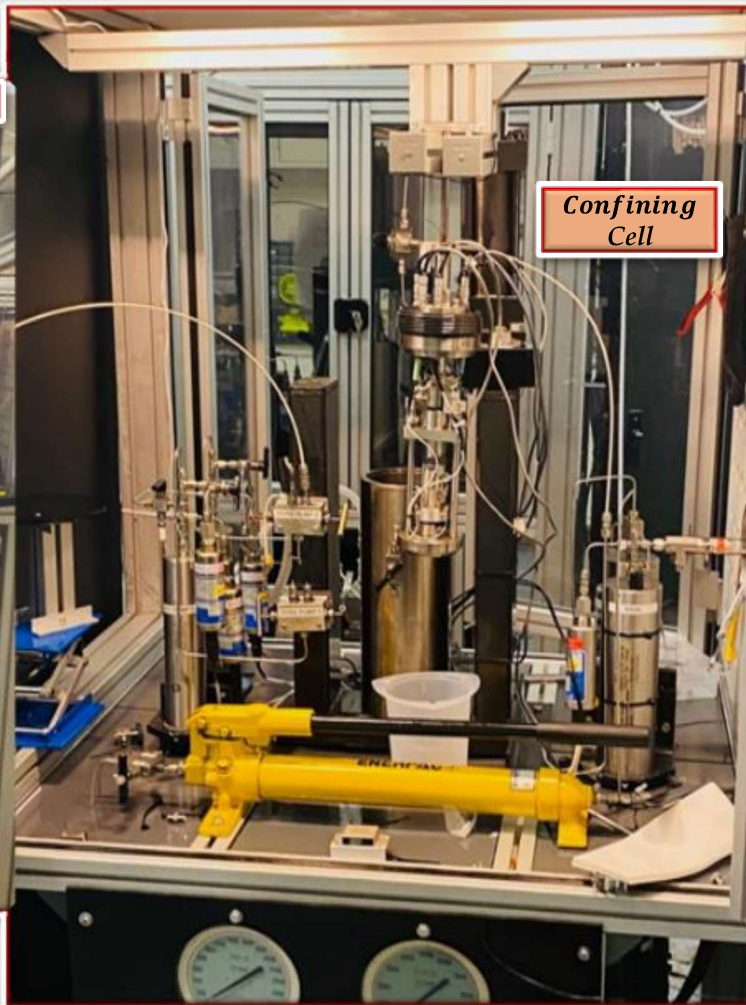


- Search for radioactive bedrock & iron-rich minerals
- Identify fracturing & faults
- Look for structural & stratigraphic traps and direct gas indicators

Experimental setup for hydrogen in rocks



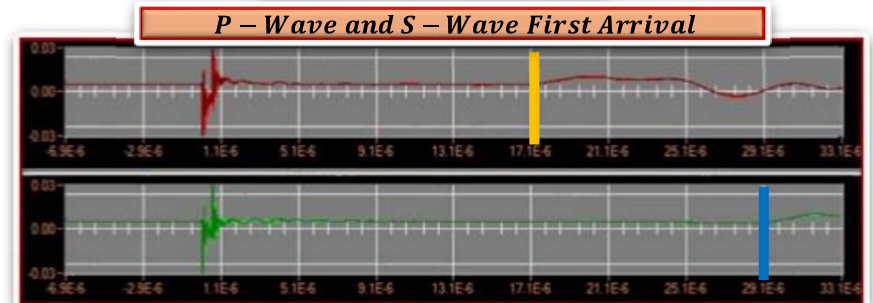
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Confining Cell

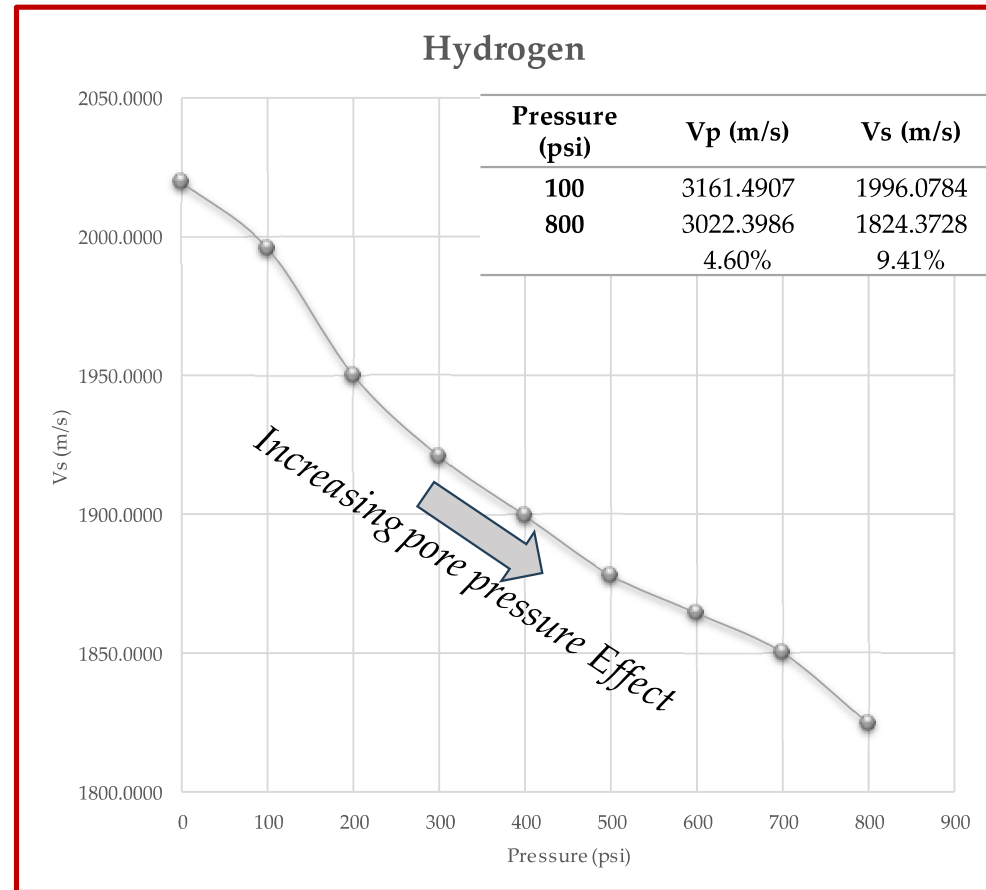
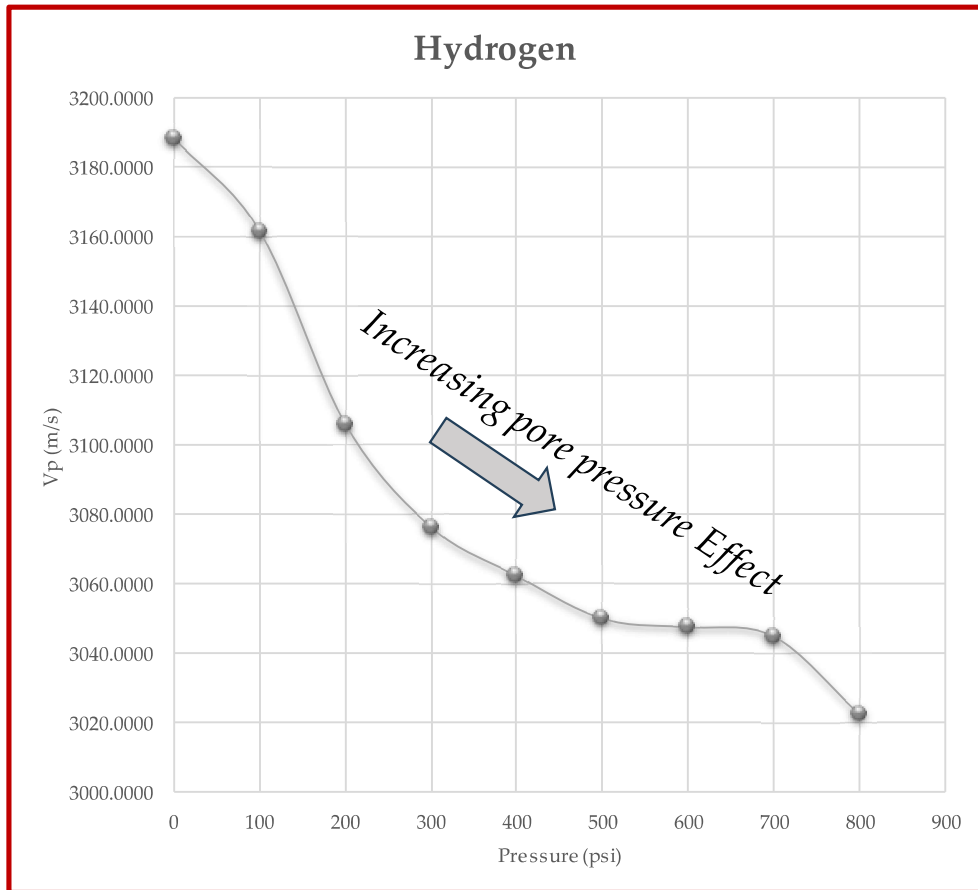


Gas Tank



P – Wave and S – Wave First Arrival

Effect of Pore Pressure - H₂



[Harbour Energy's press release](#) stated that the Timpan-1 well is located 150 kilometers north of the Island of Sumatra in the Andaman Sea, Indonesia, in a water depth of 4 245 feet. The well was drilled to a total vertical depth of 13 818 feet subsea. The well encountered a 390 foot gas column in a high net-to-gross, fine-grained sandstone reservoir with associated permeability of 1-10 mD.

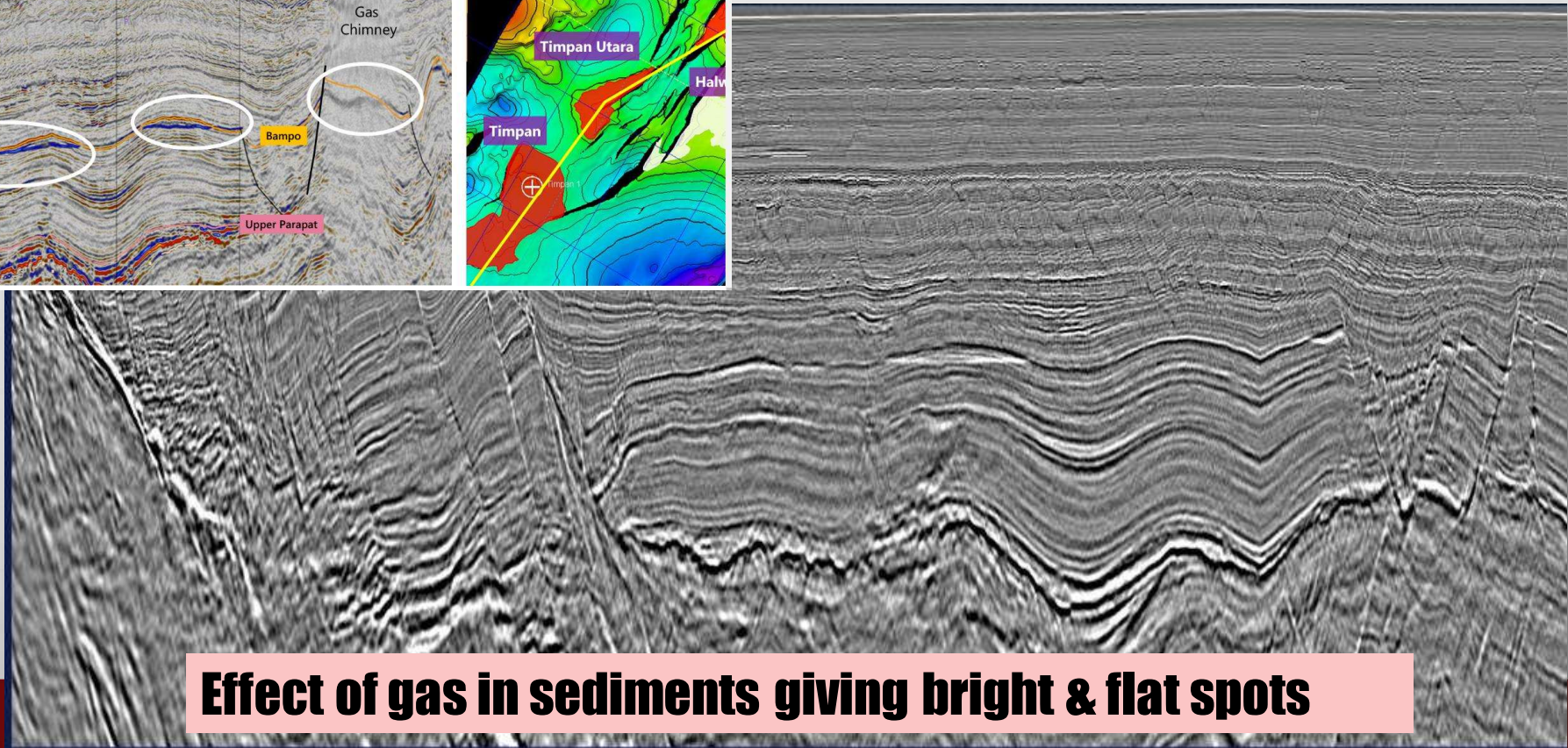
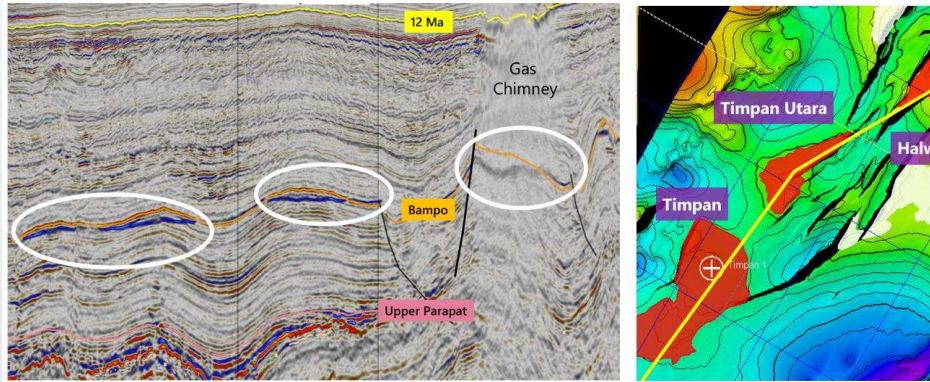
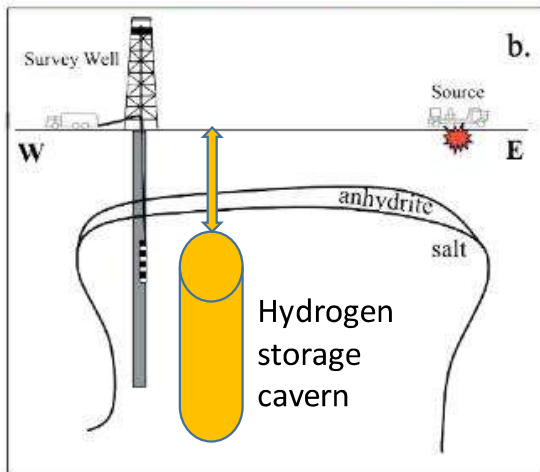
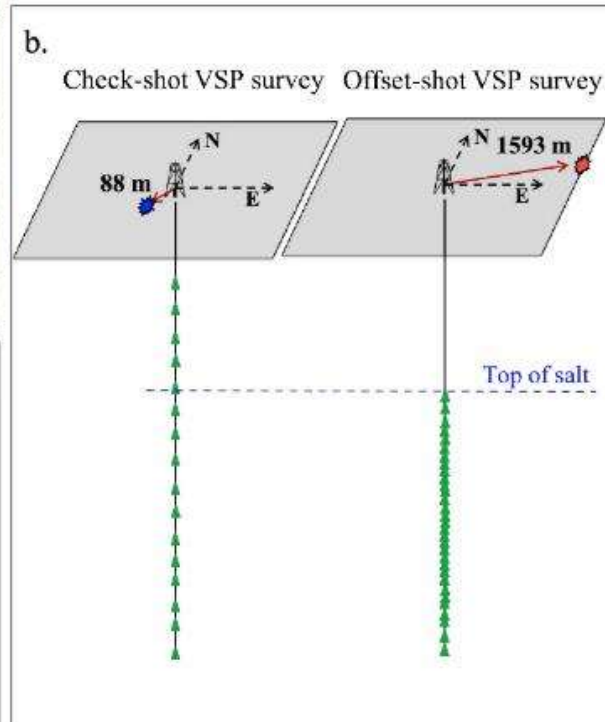
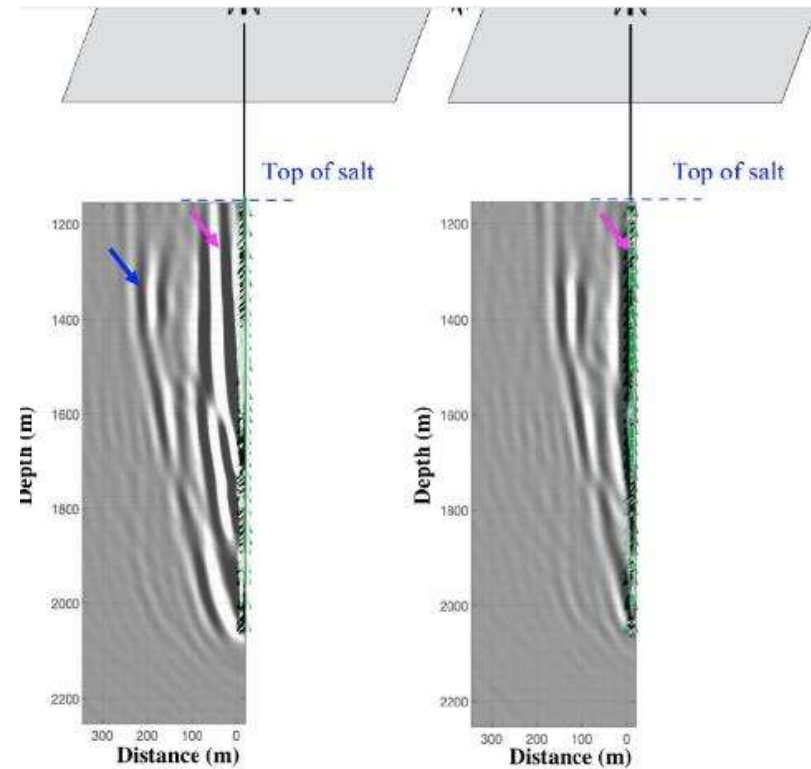


Image source: <https://www.pgs.com/company/newsroom/news/pgs-multiclient-data-in-the-north-sumatra-basin-indonesia-yields-successful-results-for-harbour-energy/>



Salt dome edge imaging with elastic events



Hydrogen Storage in Salt Caverns

Proven technology for hydrogen storage. Are there adequate domal salt resources to support the Hydrogen storage demands?

We assessed the suitability of salt domes in Texas and Louisiana for hydrogen storage in terms of geology, pipeline accessibility, and permitting

154 domes were evaluated: 54 (state of Texas), 92 (state of Louisiana), and 6 (TXLA border)

26 of the 154 domes made the first cut.

The 26 Selected Domes

County/Parish	Dome Name	Depth-salt(ft)	Depth-Caprock(ft)	Caprock Thickness	Reference Distance	Available Salt	Salt Available	Existing Cavern	Existing Well	Injection/Disposal
Texas										
Brazoria County	Allen	1,324	760	564	64.68	Yes	No	Unknown	Yes	No
Brazoria County	Stratton Ridge	1,250	850	400	53.21	Yes	Unknown	Yes	Yes	Yes
Brazoria County	Hoskins mound	1,100	574	526	44.68	Unknown	Unknown	Yes	Yes	No
Brazoria County	Clemens	1,380	530	850	63.52	Yes	Unknown	Yes	Yes	Yes
Fort Bend County	Big Creek	635	450	185	48.94	Yes	Yes	Yes	Yes	Yes
Fort Bend County	Long Point	868	550	318	49.88	Yes	Unknown	Yes	Yes	Yes
Fortbend County	Blue ridge	230	143	87	32.17	Unknown	Unknown	No	Yes	Yes
Fortbend County	Nash	950	620	330	49.9	Yes	Unknown	Yes	Yes	Yes
Hardin County	Saratoga	1,900	1,500	400	46.69	Yes	Yes	Yes	Yes	Yes
Jefferson County	Fannett	2,080	741	1,339	46.83	Yes	Yes	Yes	Yes	Yes
Jefferson County	Spindle Top	1,200	700	500	59.08	Yes	Yes	Yes	Yes	Yes
Liberty County	N Dayton	800	580	220	23.19	Yes	Yes	Yes	Yes	Yes
Liberty County	South Liberty	480	275	205	21.02	Yes	Yes	No	Yes	No
Liberty County	Hull Salt Dome	595	260	335	32.96	Yes	Yes	Yes	Yes	Yes
Liberty County	Moss Bluff	1,077	591	486	21.04	Yes	Yes	Yes	Yes	Yes
Matagorda County	Hawkinsville	450	95	355	72.2	Unknown	Unknown	Unknown	Yes	No
Matagorda County	Markham	1,417	1,380	37	88.19	Yes	Yes	Yes	Yes	Yes
Wharton County	Boling	975	383	592	62.58	Yes	Yes	Yes	Yes	Yes
Louisiana										
Cameron Parish	Black Bayou	1,035	881	154	84.73	Yes	Unknown	Yes	Yes	Yes
Lafourche Parish	Chacchahoula	1,100	875	225	245	Yes	Yes	Unknown	Yes	Yes
Iberia Parish	Iberia	805	1,078	273	199.1	Yes	Yes	Unknown	Yes	Yes
Acadia Parish	Jennings	2,512	1,900	612	149.63	Yes	Yes	Yes	Yes	
Ascension Parish	Sorrento	1,717	1,568	149	253.83	Yes	Yes	Yes	Yes	Yes
Calcasieu Parish	Vinton	700	384	316	90.5	Unknown	Unknown	Unknown	Yes	Yes
Evangeline Parish	Pine Prairie	346	Surf	346	168.21	Yes	Yes	Yes	Yes	Yes
Iberville Parish	White Castle	2,313	1,693	620	226.66	Yes	Yes	Unknown	Yes	Yes

Legend	Blue	Orange	Magenta	Red	Proposed Domes
	Best	Better	Good	Worst	
Depth to Salt	<2000	2000 - 3000	3000 - 4000	>4000	
Ref Distance	<100	100 - 200		>200	
Caprock Thickness	<500	200 - 500		<200	

Ref Distance: Distance from the Dome to ExxonMobil Baytown Plant

Summary: Hydrogen – the new classical gas

- Lots of interest & activity in hydrogen ... & *helium & carbon management*
- Substantial progress on gases and their effect on rocks
- Plenty to be done in exploration for hydrogen
- Anticipate further developments in all of the above!