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Adapting petroleum exploration tools to identify and prioritize potential CCS sites offshore Texas and Louisiana

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Abstract

Optimization of storage resource is a key parameter in siting and financing storage hubs. We invert petroleum exploration approaches at a geologic play level to assess subsurface risks to long-term storage, as a mechanism to lower cost and increase security. Basin-scale screening, play definition and prospect description are core tasks of petroleum exploration however and there is a well-defined suite of tools to deal with the problem. The work described here adapts those tools to the identification of CCS sites, using the U.S. Gulf of Mexico basin as a timely example.

The approach is essentially a three-part one. First, we use regional cross-sections to identify and describe potential storage plays. Second, we use maps of layered surface and subsurface elements to describe the suitability of potential sites, based on the areal quality variation of available reservoirs and seals, the locations of potential traps and CO_2 sources, and the distribution of surface constraints such as land usage, available infrastructure and accessibility. Third, we use risk matrices and historical analog data from petroleum exploration to describe the subsurface risks to successful project delivery.

With respect to the Gulf of Mexico, CO_2 source locations, current land use, site access and the density of existing well penetrations all favor offshore storage. Accordingly, we have focused our efforts on the coastal waters of Texas and Louisiana, constructing a series of exploration-inspired cross-sections and maps that serve both to help adapt the tools of exploration for CCS and to identify and high-grade potential storage sites in coastal waters. The depth window for CO_2 injection is defined by subsurface temperature and fluid pressure. Specifically, it lies between the minimum depth for supercritical CO_2, which lies at roughly 1km depth and the top of hard over-pressure, which varies between 1.5 and 4km depth, based on extensive drill data. Within this window, stratal ages vary from Early Cretaceous at the northern (onshore) basin edge to Plio-Pleistocene in the south (offshore), reflecting the long-term progradation of depositional systems toward the basin. For each of these stratigraphic intervals, play fairways are defined by a regional seal and its underlying reservoirs. Focussing on the coastal region (i.e. the Oligo-Miocene), we construct a series of maps for each play. The first describes the regional variation in seal capacity (essentially the clay fraction, calibrated by known hydrocarbon columns). The second and third

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describe reservoir presence and quality, respectively. Historically such maps are based on depositional environment and sediment provenance and they tend to show rather blocky distributions. In an effort to more faithfully represent geologic variability and gradational transitions, we experiment with using modern algorithms and large log databases to create a more variable visualization.

Site selection will determine maximum injection rate, ultimate storage capacity and risk of future leakage. In short, regional subsurface characterization is critical to planning investment and may spell the difference between storage project success and failure. Together, the maps developed here describe the regional variation in storage capacity. Combined with maps of surface factors such as accessibility, land ownership, existing land use and CO_2 point source locations, they clearly prioritize areas of the basin for investment in infrastructure and development of large-scale storage projects. Adding potential local traps to the map defines a series of concrete leads for storage sites that can be evaluated in more detail as needed for specific projects.

Keywords: Gulf of Mexico; exploration; CCS, geologic storage; reservoir; seal;