Model of CO_2 Leakage Rates Along a Wellbore

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The flux of CO_2 along a leaking wellbore requires a model of fluid properties and of transport along the leakage pathway. Most models to date treat transport as a Darcy continuum. We argue here that the transport model should accurately represent the geometry of any discrete leakage pathway (fracture, microannulus, channel), because this geometry strongly affects the coupling between geochemical reactions and geomechanical responses. This coupling is of particular concern when CO_2 and/or CO_2-saturated brine contact cement.

Wells that exhibit sustained casing pressure (SCP) are a good analog to study the models of transport along a leakage pathway. Applying a SCP model to field data yields information about the depth of the leakage source and effective permeability of the pathway. The effective permeability can be interpreted quantitatively in terms of the dimensions (aperture) of discrete pathways, such as a gas channel, micro fracture, or micro annulus.

We develop a new model that incorporates CO_2 properties in a discrete pathway along a wellbore. It can accurately assess long term fate of CO_2 leakage provided the information about the depth of leak and pathway geometry and dimensions. This approach can provide a probabilistic distribution of leakage rates given regional and well parameters. The model provides a foundation for studying the effect of geochemical/geomechanical coupling on leakage rates. For CO_2 sequestration purposes this provides a tool to assess the risk of carbon dioxide escape along leaky wells, which is necessary for site selection, permitting, and properly crediting sequestration operations.

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