Integrated Reservoir Connectivity Analysis, Zechstein Carbonate Reservoir, Northern German Basin*

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Abstract

An integrated workflow is presented for evaluating static and dynamic connectivity of a complex Upper Permian Zechstein Ca2 carbonate reservoir, mainly platform facies, in the Scholen Concession of the Northern German Gas Basin. Sour gas production in the concession began in 1963 and involves drainage from multiple, tectonically emplaced and, in places, vertically stacked allochthonous Zechstein carbonate reservoir sections. These allochthons lie within the Permian Zechstein salt and overlie the in-place autochthonous Zechstein reservoir.

The key issues in the Scholen Concession are the static connectivity and fill-and-spill scenarios among the multiple Zechstein sour gas accumulations and the dynamic connection between the autochthonous and allochthonous reservoir sections. Understanding these issues is important in the evaluation of infill drilling opportunities and near-field appraisal wells, and whether or not these opportunities can be drilled economically.

The applied integrated workflow consists of six main steps (Figure 1): 1) plot well data to define fluids and fluid levels; 2) evaluate static fluid pressure data to determine original (geologic time scale) reservoir connectivity and potential fluid compartments; 3) integrate geology and fluid pressure data to link the fluids to the geology; 4) construct a reservoir connectivity diagram to map the probable/potential connections between compartments; 5) evaluate dynamic (production time scale) reservoir connectivity using production data to identify baffles or barriers between compartment boundaries; and 6) apply learnings to drill-well evaluations.

This integrated reservoir connectivity analysis incorporating geoscience and reservoir engineering data (i.e., linking the fluids to the geology) revealed that the five main gas accumulations in the concession appear to be connected statically through a common aquifer and the in-place autochthon, and most detached allochthons likely are connected dynamically with baffles (impeded flow across these tectonic reservoir boundaries) (Figure 2). Some allochthons are isolated and contained high pressured reservoirs that are either gas or water bearing. These isolated allochthons are difficult to distinguish from connected allochthons from geoscience analyses. Previous view of the Scholen Concession was that the five main accumulations were in separate, unconnected compartments and that most allochthons were not in dynamic pressure communication.

These learnings ultimately led to realistic and reliable evaluations of infill opportunities and near-field appraisals in the concession area, and changes to the drill-well inventory seriatim. Initial pressure and related resource capture were amended for infill well locations, and pressure depletion, drainage, and leakage risks were critically assessed for near-field appraisal wells. The potential of encountering isolated allochthons is still difficult to predict and, thus, is incorporated in the risking and uncertainty analysis of associated drill-well leads. In conclusion, this type of integrated reservoir connectivity analysis is essential in developing an understanding of the interrelationship of fluids and geology in the subsurface and can be applied not only in a production setting, but throughout the exploration, development, and production business cycle.

Integrated Reservoir Connectivity Analysis (IRCA) Workflow

Step 1: Plot Well Data to Define Fluids & Fluid Levels

Step 2: Evaluate Static Fluid Pressure Data

Step 3: Integrate Geology & Fluid Pressure Data

Step 4: Construct Reservoir Connectivity Diagram

Step 5: Evaluate Dynamic Reservoir Connectivity

Step 6: Apply Learnings to Drill-Well Evaluations

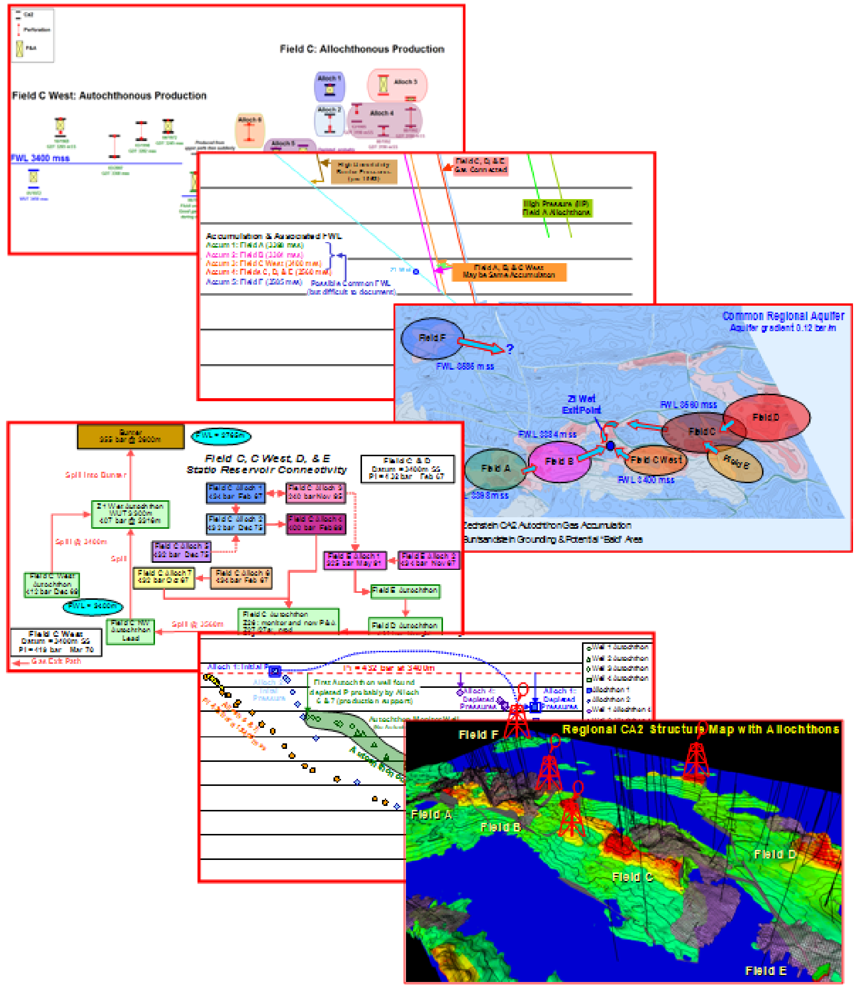

Figure 1. Integrated reservoir connectivity analysis (IRCA) workflow.

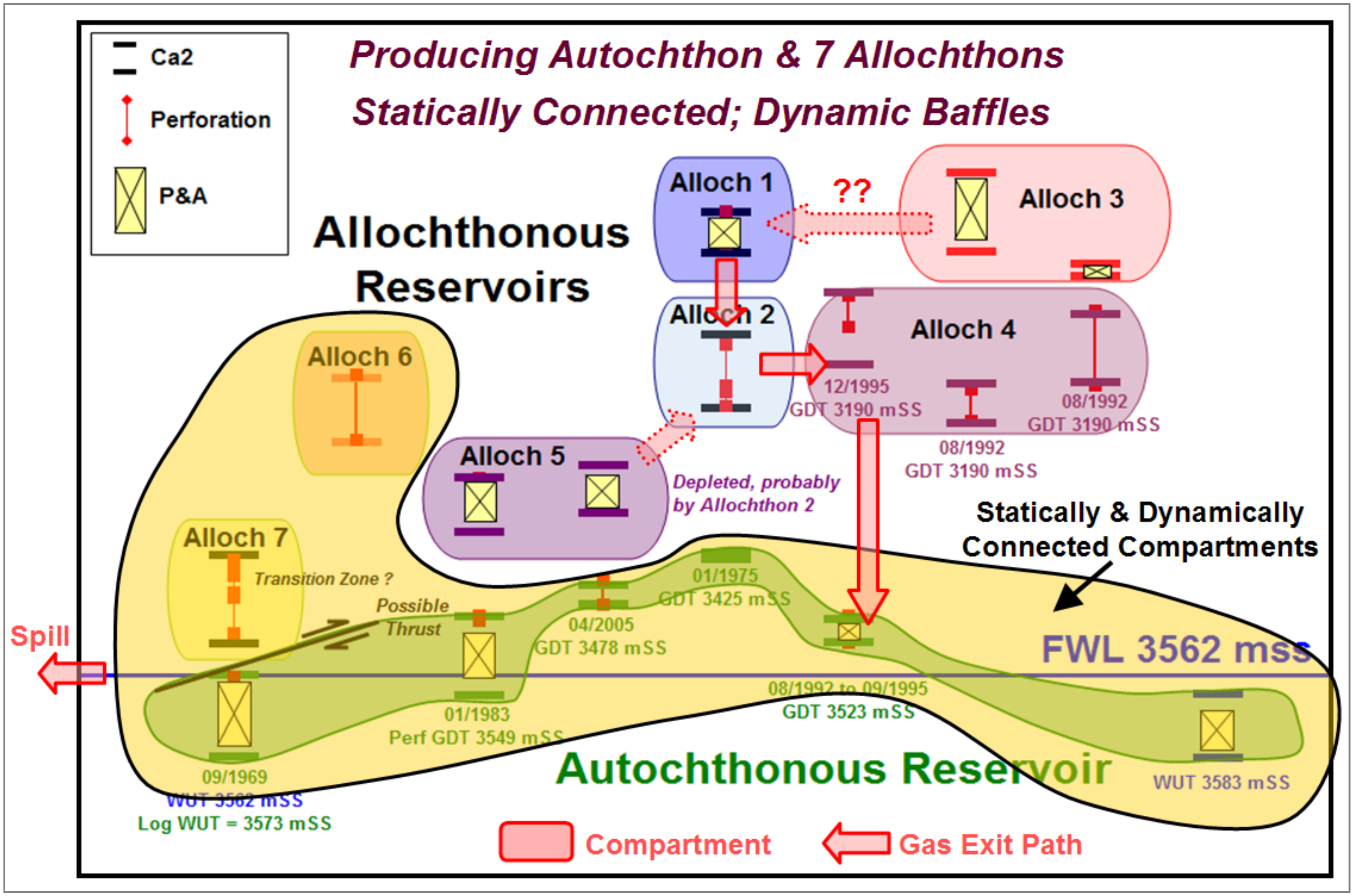

Figure 2. Field C dynamic reservoir connectivity analysis results.