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# Finding Bypassed Pay in Complex Channel Sands with Interwell Surveys

## Reservoir-scale resistivity surveys by Deeplook-EM service identify bypassed pay in Gudao field, China

### CHALLENGE

Obtain field-wide information to optimize waterflood and find bypassed pay in channel and sheet sand reservoirs of Gudao field.

### Solution

Conduct three surveys with DeepLook-EM* crosswell electromagnetic imaging service to track fluid displacement within the mature waterflood area.

### Results

Characterized the interwell sand-shale formations and identified a bypassed oil zone that is now being produced.

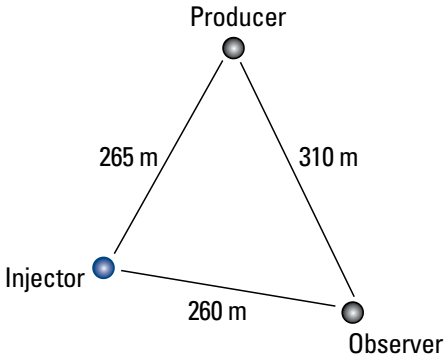
### Understanding a challenging environment

Gudao field in central China is a challenging production environment. The reservoirs are in both discrete channels and continuous deltaic sheet sands within an anticlinal trap. Waterflooding has been most effective in Zones 3 and 4, which are well-defined, continuous deltaic sands that range in thickness from 4 to 12 m [13 to 29 ft]. Recovery has not been as successful from Zone 5, which is less continuous and contains heavier oil. A cyclic steaming strategy has achieved some success in Zone 5.

China Petroleum & Chemical Corporation (Sinopec Corp.) wanted to better understand the configuration of the sands in relation to the controlling structure because that knowledge is crucial for optimizing waterflooding and locating bypassed reserves. However, conventional logging results could not be easily interpolated between wells because of the complexity of the faulted sand-shale formations.

### Surveying crosswell resistivity

To remedy the lack of interwell information, DeepLook-EM crosswell electromagnetic imaging service was used to conduct surveys in a set of three wells. Although the well conditions included steel cased and open hole, DeepLook-EM service provided reservoir-scale resistivity images for tracking fluid displacement within the reservoir without the uncertainties introduced by interpolating single-well data to field scale in a heterogeneous reservoir.

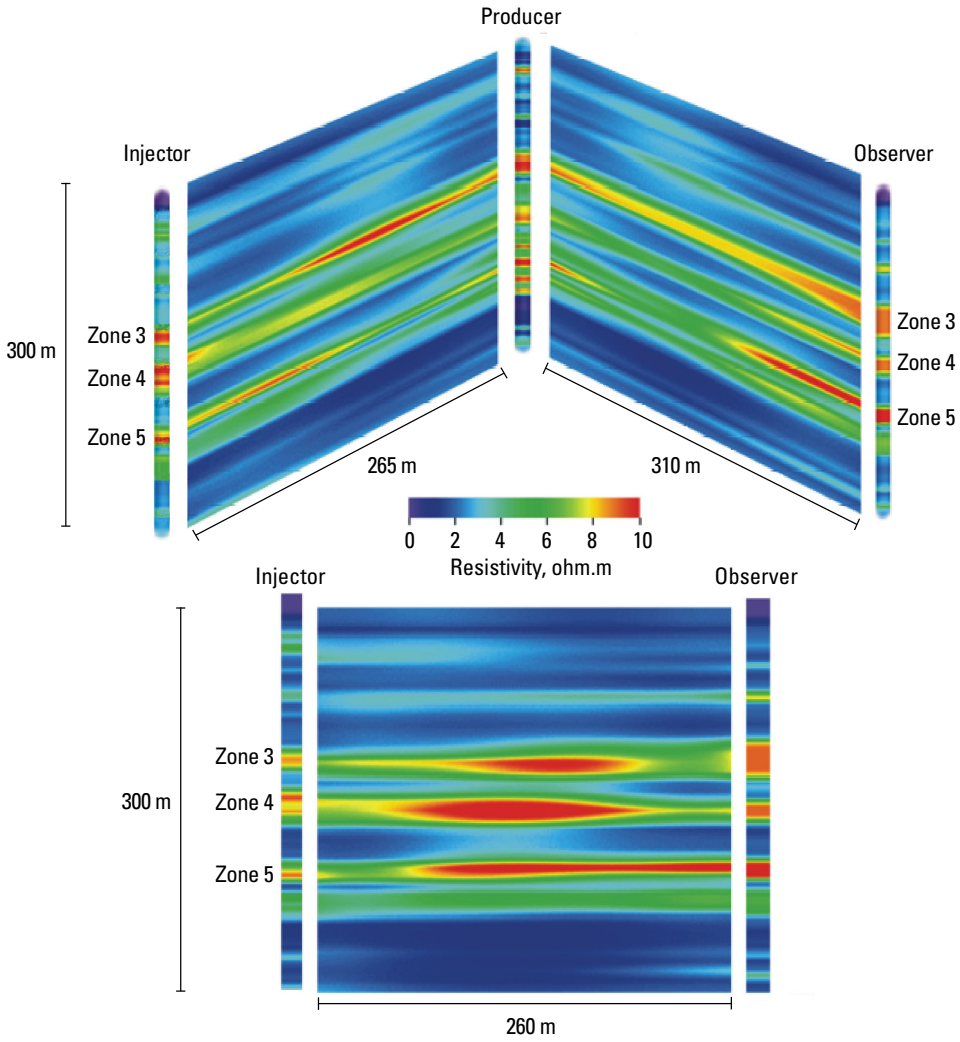



*DeepLook-EM service ransmitter and receiver tools were run in pairs of the three wells.*

### Determining formation resistivity and thickness

The steel-cased wells were logged with the CHFR* cased hole formation resistivity tool to account for resistivity changes after 20 years of production and injection. These accurate resistivity measurements were used to calibrate the baseline model for processing the data from DeepLook-EM service.

In the DeepLook-EM service image between the producer and injector wells (left panel), the smooth image is consistent with multiple flat layers and concordant with the CHFR tool's well logs. The low-resistivity upper section consists of clays and silts with thin, discontinuous higher resistivity sands that may be oil bearing.




*DeepLook-EM service's crosswell resistivity images between the three wells show that the three producing zones are mostly consistent in thickness and continuity. The higher resistivity in Zone 5 indicates bypassed oil.*

The producing Zones 3, 4, and 5 are continuous high-resistivity layers. Zone 3 does not vary in thickness but decreases in resistivity from the producer well toward injector well. Zone 4 has a constant resistivity but thickens gradually toward the injector well. Both Zones 3 and 4 show slight stratigraphic thinning in relation to variation in the overburden. Zone 5 is the most variable, grading from four layers at the injector well to two or three layers at the producer well. DeepLook-EM service's image in the right panel is similar to that between the producer and injector wells, with minor thickness variations and the gradation of Zone 5 to fewer layers.

Sinopec Corp. wanted to confirm sweep efficiency. The lower panel clearly indicates large zones of unswept pay (red) between wells. Sinopec Corp. confirmed this result by correlation of the resistivity log from a subsequently drilled well located near the bypassed pay indicated by the DeepLook-EM service survey.

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