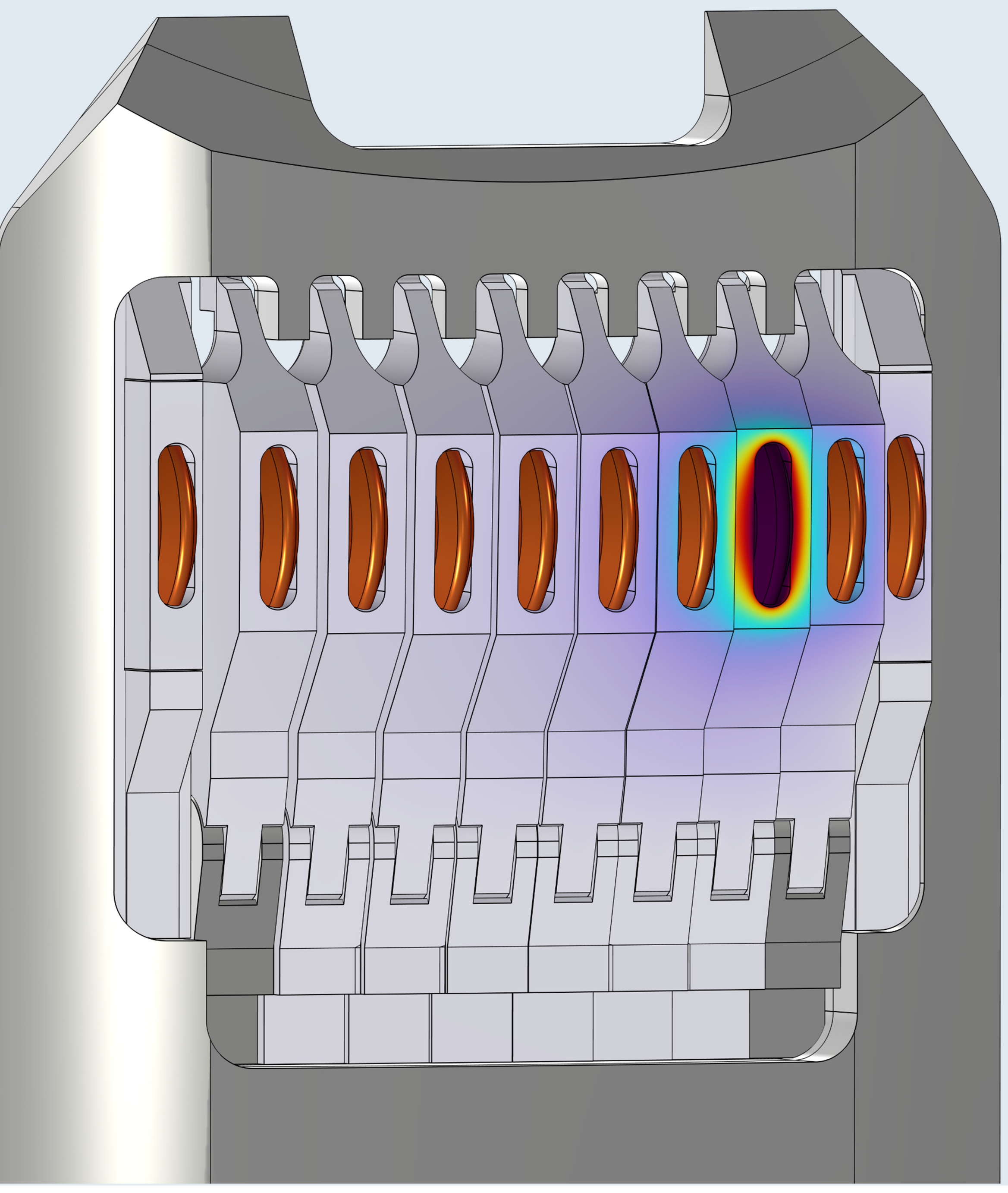

Modelling of a Knife-Based Microimager: Thin Bed Analysis

This work characterises the vertical resolution of knife-based microimagers; borehole imaging tools used to produce subsurface images from shallow resistivity readings.

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Introduction

Electrical borehole imaging is a geophysical well logging operation used to produce subsurface geological images from shallow resistivity readings using tools termed as microresistivity imagers. Geological features such as thin beds, structural features and fractures can be identified from these high-definition resistivity images [1]. In the case of electrically non-conductive borehole fluids, pad-type imaging tools need to create an electrical contact through the borehole wall, allowing an alternating current to flow into the formation and return to the tool. The electrodes in knife-blade microimagers are designed to cut through any mud cake that lines the borehole wall, allowing a path for current flow into the formation. Imaging tools are characterized by hole coverage, resolution, and depth of investigation (DOI). This work focuses on the characterisation of the vertical resolution of a knife-blade microimager through thin bed modelling to determine the resolution of the apparent resistivity value to bed thickness.

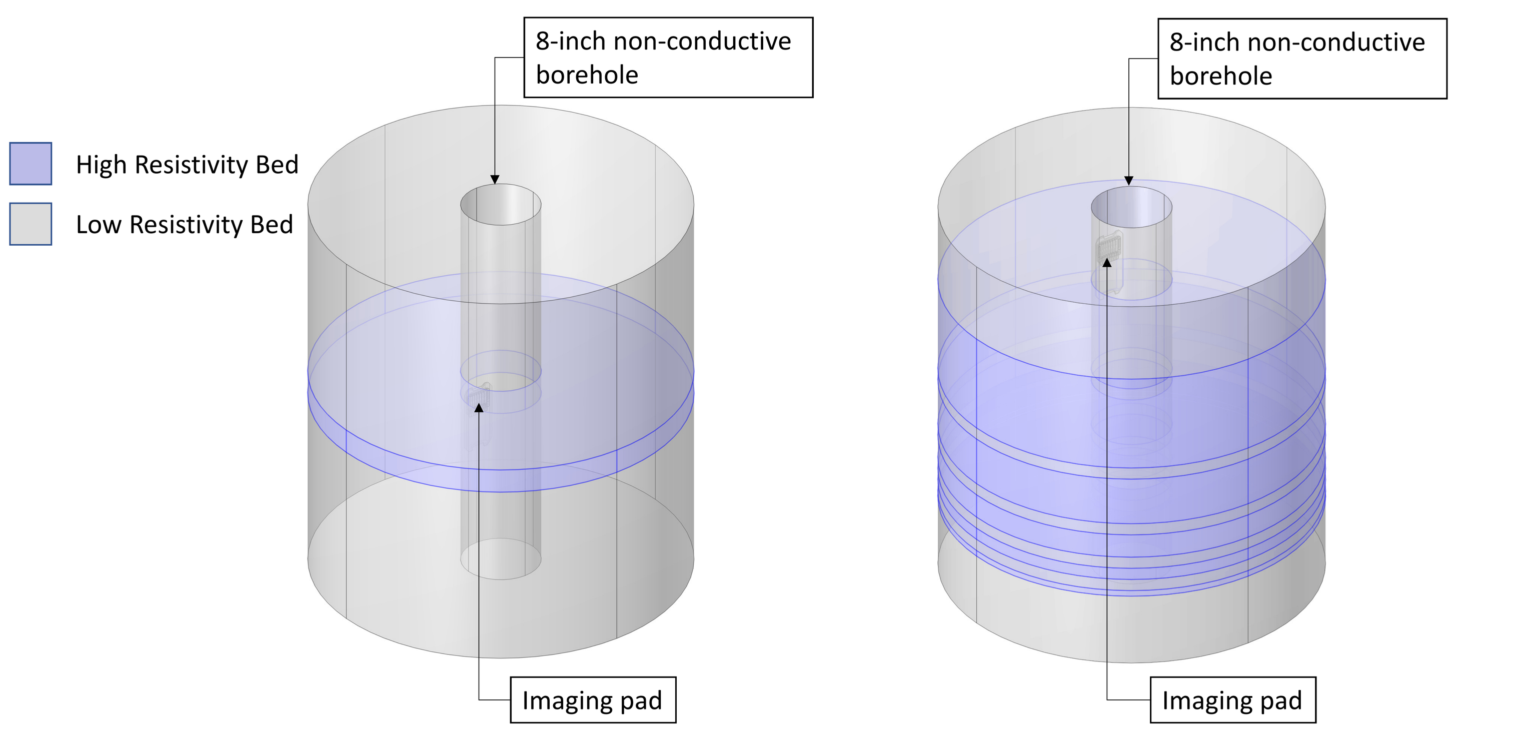

Figure 1. Left: 3 bed model with a 1:10 resistivity contrast. Right: Multiple bed model with either 1:10 or 1:5 resistivity contrast with different bed thicknesses.

Methodology

A 3D model of a 10-electrode imaging pad was imported and simplified, and formations, consisting of multiple beds, were modelled. Thin bed modelling is widely used to determine the minimum bed thickness that the imaging tool can detect [2][3]. Figure 1 shows a 3-bed model, in which the bed thickness was varied between 0.25" and 2", and a multiple bed model, in which adjacent beds ranged between 0.5" and 8". A small DC current excitation was applied to an electrode, an adjacent electrode was used to measure the potential difference, while the pad face acted as a ground. The imaging pad was moved through the bed boundaries, where voltage and current were measured to calculate resistance. A k-factor, derived via modelling, was then used to convert resistance to resistivity.

Results

The synthetic responses from the thin bed models were used to determine the resolution of the tool. To assess these responses, two important aspects need to be looked at. The first aspect is whether the tool can distinguish thin beds from nearby beds. Figure 2 shows that beds with a thickness of at least 0.5" are clearly distinguishable. The second aspect is how accurate the measurements are to the actual formation resistivity. Figure 2 shows that as the thickness of the bed decreases, the apparent resistivity and accuracy decrease. The peak apparent resistivity of the 2" bed is within 11% of the actual resistivity, whereas the peak apparent resistivity of the 8" bed is within 3%.

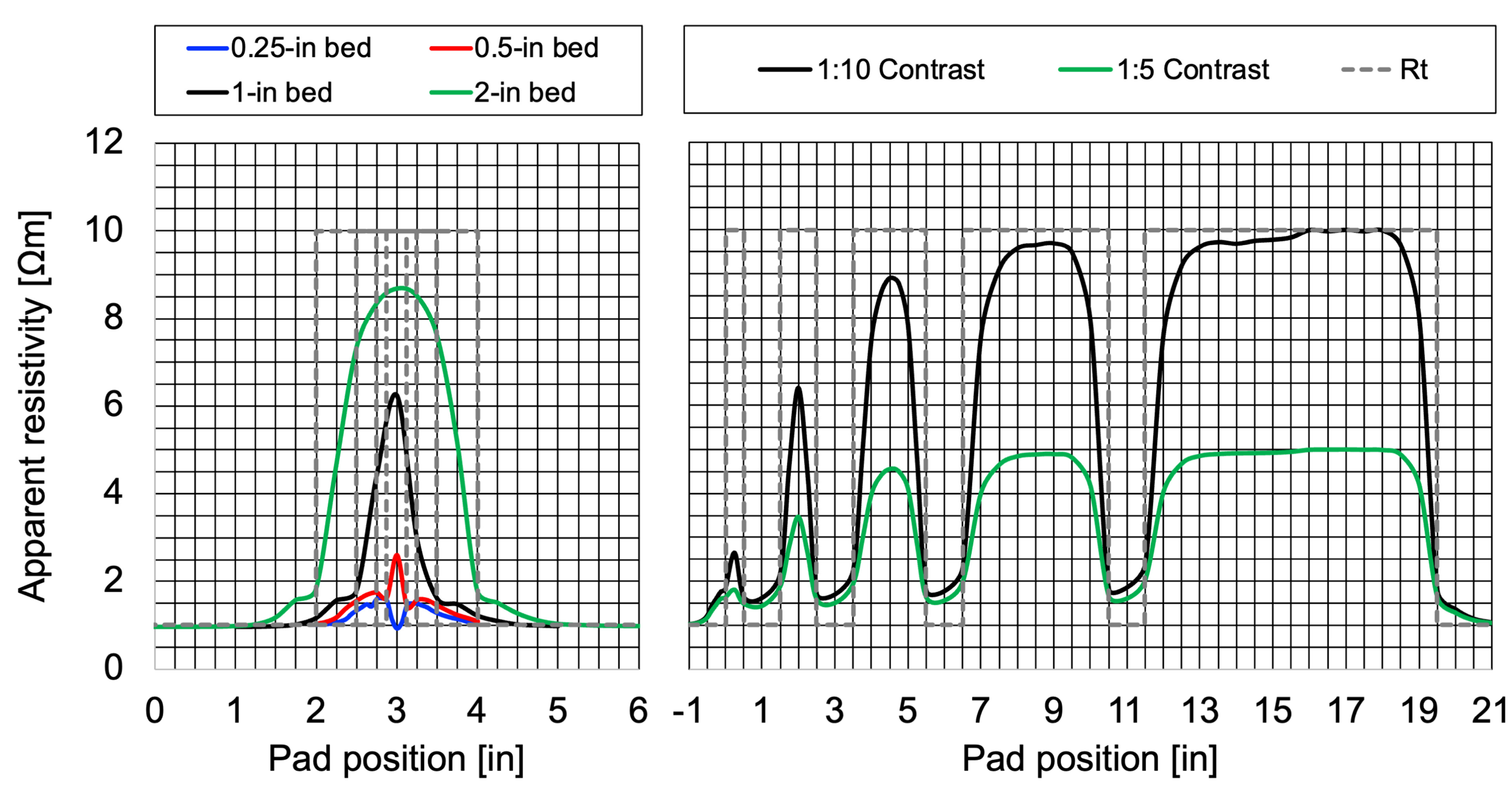

Figure 2. Left: The resistivity responses to a 10Ohm bed in a 1Ohm background. Right: The resistivity responses to 10Ohm and 5Ohm beds of increasing thickness, separated by a 1", 1Ohm background.

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