# Past, Present, and Future Applications of Ultra-Deep Directional Resistivity Measurements: A Case History from the Norwegian Continental Shelf

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**Authors** : **Supriya Sinha, Arthur Walmsley, Nigel Clegg, Brígido Vicuña (Halliburton), Andrew McGill, Téo Paiva dos Reis, Marianne Therese Nygård, Gunn Åshild Ulfsnes, Monica Vik Constable, Frank Antonsen and Berit Ensted Danielsen (Equinor)**

**Speaker** : **Supriya Sinha, Arthur Walmsley**

**Abstract:**

With the introduction of Ultra-deep azimuthal resistivity (UDAR) logging while drilling (LWD) tools towards the beginning of the last decade, the Oil and Gas industry went from real time mapping of formation boundaries a few meters from the wellbore to tens of meters away. This innovation allowed early identification of resistivity boundaries and promoted proactive geosteering, allowing for optimization of the wellbore position. Additionally, boundaries and secondary targets that may never be intersected are mapped, allowing for improved well planning for sidetracks, multi laterals and future wells. Advancement in tool design and inversion algorithms has allowed mapping the reservoir in 3D and exploring the sensitivity of these tools ahead of the measure point to provide look ahead warning of resistivity boundaries. Improvements in the technology over the decade have changed the way wellbores are planned, drilled, completed and reservoir models are updated. This paper presents a case study summarizing the advances in UDAR measurements and inversions over the last decade. The case study presents the whole workflow from pre-job planning, service design and execution of 1D and 3D inversion in addition to the future potential of look ahead in horizontal wells. Prewell simulations provide a guide to expected tool responses real-time in the highly heterogeneous formations. This validates how far from the wellbore 1D inversions can map major boundaries above and below the well. A fault was expected towards the toe of the well, UDAR was used as a safeguard to avoid exiting the reservoir. Standard 1D inversion approaches are too simplistic in this complex geologic setting. Thus, 3D inversion around the wellbore and ahead of the transmitter is also explored to demonstrate the improvements this understanding can bring regarding geostopping towards the fault and reservoir understanding in general. Successful geosteering requires personnel trained to handle the uncertainties. A geosteering training simulator (GTS) could be an efficient tool for training, to interpret inversions where the “truth” is known from realistic 3D model scenarios. The team can learn how to best exploit UDAR-technology and inversion results within its limits and not extend the interpretation beyond acceptable uncertainty levels. It will also be addressed how the understanding of inversion uncertainty could be updated real-time in the future. Continued future success of UDAR-technology and 1D – 3D inversion results for look ahead and look around applications will depend heavily on uncertainty management of the inversions to avoid wrong decisions and potential reduced well economy.

**Bio:**

**Supriya Sinha** is geosteering lead at Halliburton, based in Norway. Sinha joined the oil and gas industry in 2006 as a mudlogging geologist, then moving on to data engineer and log analyst. She began her career with Halliburton in 2010 as a drilling optimization engineer (ADT) in India and Malaysia, then in 2012 progressed into a geomechanics consultant role for Scandinavia. From mid-2017, Sinha began working as a geosteering geologist specializing in applications of ultra-deep resistivity and is currently leading the geosteering team in Norway. Sinha holds a master’s degree in geology. She is a member of SPWLA, SPE, EAGE and AAPG.

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**Arthur Walmsley** is the 3D EM inversion subject matter expert for the eastern hemisphere at Halliburton. Walmsley joined Halliburton in 2007 and has held various technical positions in logging and well placement in the UK, Europe and Africa region. He holds a BSc in Oceanography from Southampton University, UK. He is a member of SPE, SEG, SPWLA and EAGE.