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Subsurface mapping of marlstone and limestone facies in the Silurian bedrock of Gotland, by use of Radiomagnetotelluric (RMT) methods

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The Silurian bedrock on the island of Gotland in the central Baltic Sea is composed of a series of stacked carbonate platforms. Up to 10 cycles of shallow marine back reef, reef and fore reef limestone overlie and interfinger with shallow shelf marl and marlstone deposits. Three main regional, up to 70 m thick limestone dominated bodies with high electrical resistivity are clearly marked in the electromagnetic map. The subsurface structural framework of the different lithofacies is at presently less well known. There is therefore a great interest to develop and test the applicability of different geophysical methods for this purpose. Especially as the limestone bodies constitute important groundwater aquifers and raw material to the lime and steel industry. The primary aim of this investigation is to assess the application of the RMT method regarding obtaining information on the thickness of the limestone body and the subsurface distribution of different lithofacies on central Gotland. RMT is an electromagnetic method that make use of distant radio transmitters in the frequency range between 10-250 kHz. A significant difference in resistivity between the limestone (1 000–10 000 Ωm) and the marlstone ($<$100 Ωm) gives favorable conditions to map these lithologies by use of the RMT method. Three, up to 4.3 km long profiles were measured in a test area on central Gotland covering the Klinteberg Formation and Hemse Group boundary. Adjacent borehole data were used to calibrate and evaluate the measurements. The results give a clear distinction of 2-3 bedrock units and layers with different resistivity. The high resistivity limestone observed in the airborne electromagnetic survey on central Gotland is in the RMT profiles verified to have a subsurface extension of several tens of meters. This unit overlies in general low resistivity layers corresponding to marlstone dominated lithologies. A very low resistivity layer is in addition found at depths between 80 and 120 m, which correlate to increasing amount of chlorides in the ground water. The vertical resolution of the different layers in the RMT model is in the range of $\pm$5 m and far better than any other geophysical method tested in this setting. The RMT method is in conclusion found to be a very useful method to map and distinguish between limestone and marlstone lithologies. The high resolution as well as lateral visualisation of layers renders good possibilities to perform detailed subsurface characterisation of carbonate settings like the ones found in the Silurian on Gotland.