Airborne and Ground Electrical Surveys for Subsurface Mapping of the Arbuckle-Simpson Aquifer, Central Oklahoma

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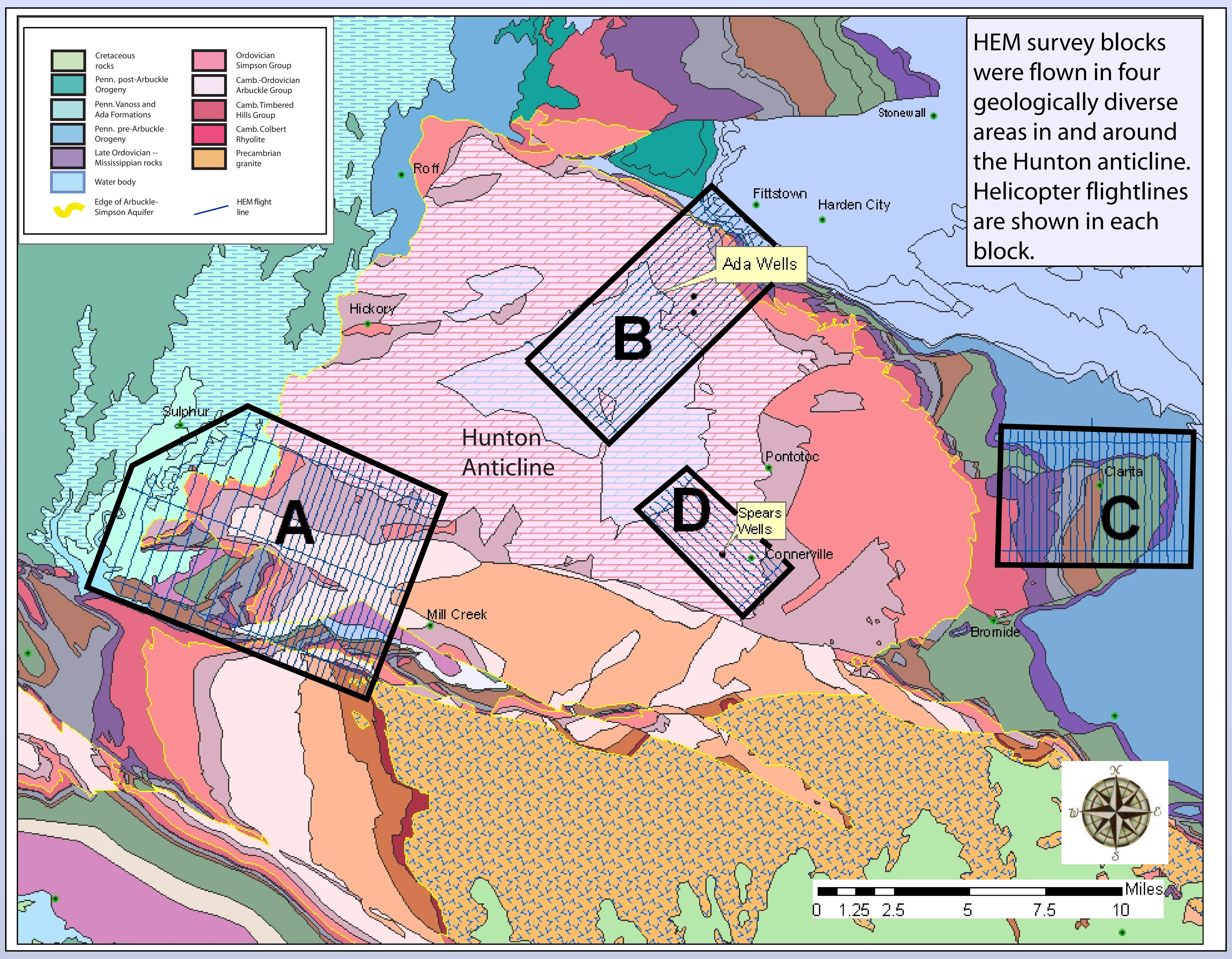
PANEL 1 Introduction

Abstract

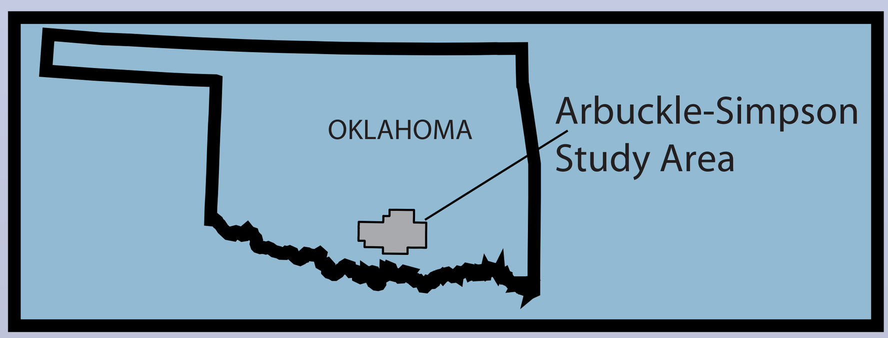
Airborne and ground electrical surveys have been conducted to map the subsurface hydrogeologic character of the Arbuckle-Simpson aquifer in south-central Oklahoma. An understanding of the geologic framework and hydrogeologic characteristics is necessary to evaluate groundwater flow through the highly faulted, structurally complex, carbonate aquifer. Results from this research will further understanding of the aquifer and will assist in managing the water resources of the region. The major issues include water quality, the allocation of water rights, and the potential impacts of pumping on springs and streams. Four areas in the Hunton anticline area, with distinctly different geology, were flown with a frequency domain helicopter electromagnetic system (HEM) in March, 2007. Ground electrical studies include dc resistivity imaging, natural field audiomagnetotelluric (AMT), and magnetotelluric (MT) surveys.

The HEM resistivity and total field magnetic survey was flown in four blocks, A through D, mostly with a line spacing of 400 m. Block A extends from the Chickasaw National Recreational Area (CHIC) to Mill Creek on the west side of the anticline. The surface geology of this block is mostly dolomitic limestone of the Arbuckle Group that is in fault contact with younger Paleozoic clastic rocks. The flight line spacing was 800 m in the western half of the block and 400 m in the eastern part. Airborne magnetic data indicate that the Sulphur fault bends south to merge with the Mill Creek fault, substantiating an earlier hypothesis first made from interpretation of gravity data. Block B, located on the north side of the anticline, consists of mostly Arbuckle and Simpson Group rocks. Block C, covering most of the Clarita horst on the east side of the anticline, consists of the Upper Ordovician to the Lower Pennsylvanian shales. Block D, which was flown to include a deep test well site at Spears ranch, consisted of eight lines spaced at 400 m.

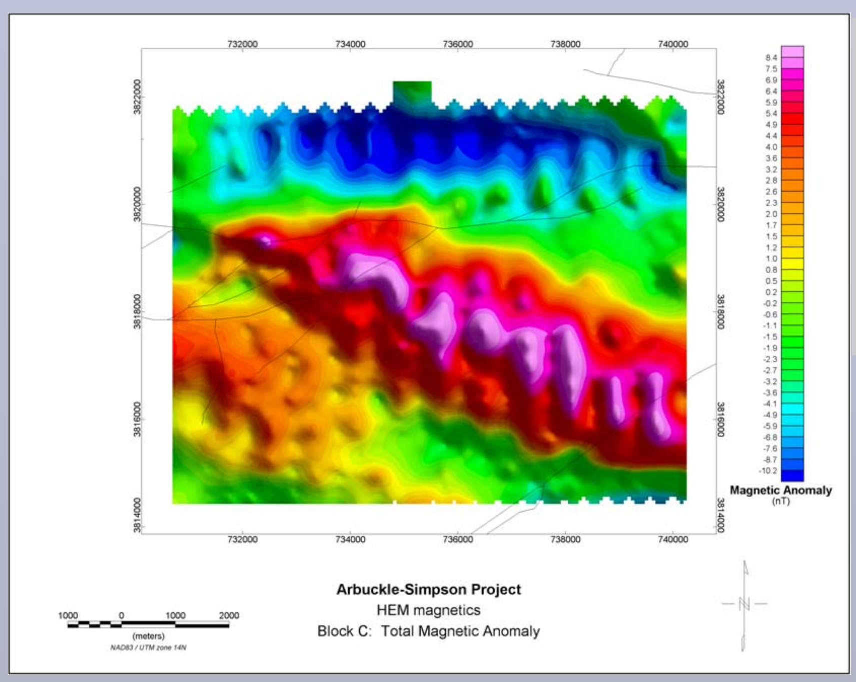
The HEM data are being used to more precisely locate faults, to refine the lithostratigraphic units, and to map the depth and extent of shallow epikarst. The MT and AMT data revealed deep structural contacts and a transition between fresh and highly mineralized ground water between springs in the CHIC. The dc resistivity survey has greatly helped in mapping major faults both within dolomitic limestone and clastic units. Ground resistivity surveys suggest that, in places, the faults within limestone are zones of lower resistivity. The dc resistivity surveys also map low resistivity surficial epikarst a several meters thick. Ground penetrometer data have been used to define the depth extent of epikarst in selected areas, and the data correlate well with the dc resistivity and HEM resistivity depth sections.



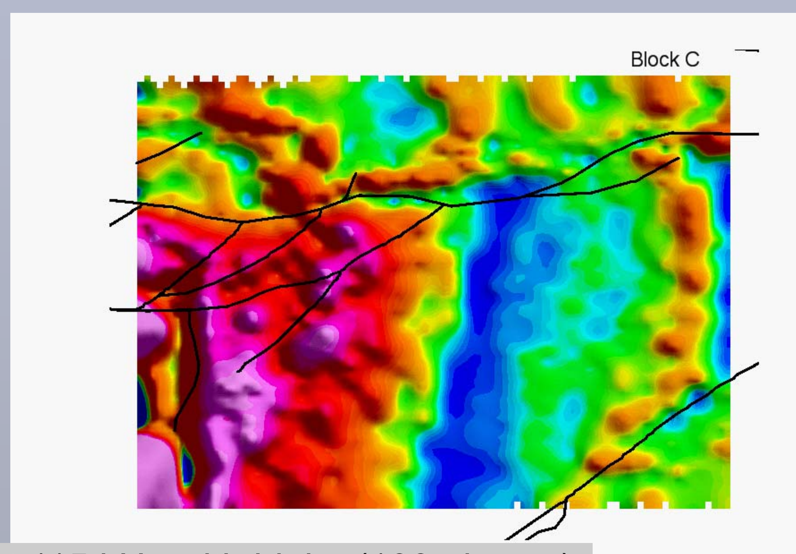
HEM survey blocks were flown in four geologically diverse areas in and around the Hunton anticline. Helicopter flightlines are shown in each block.



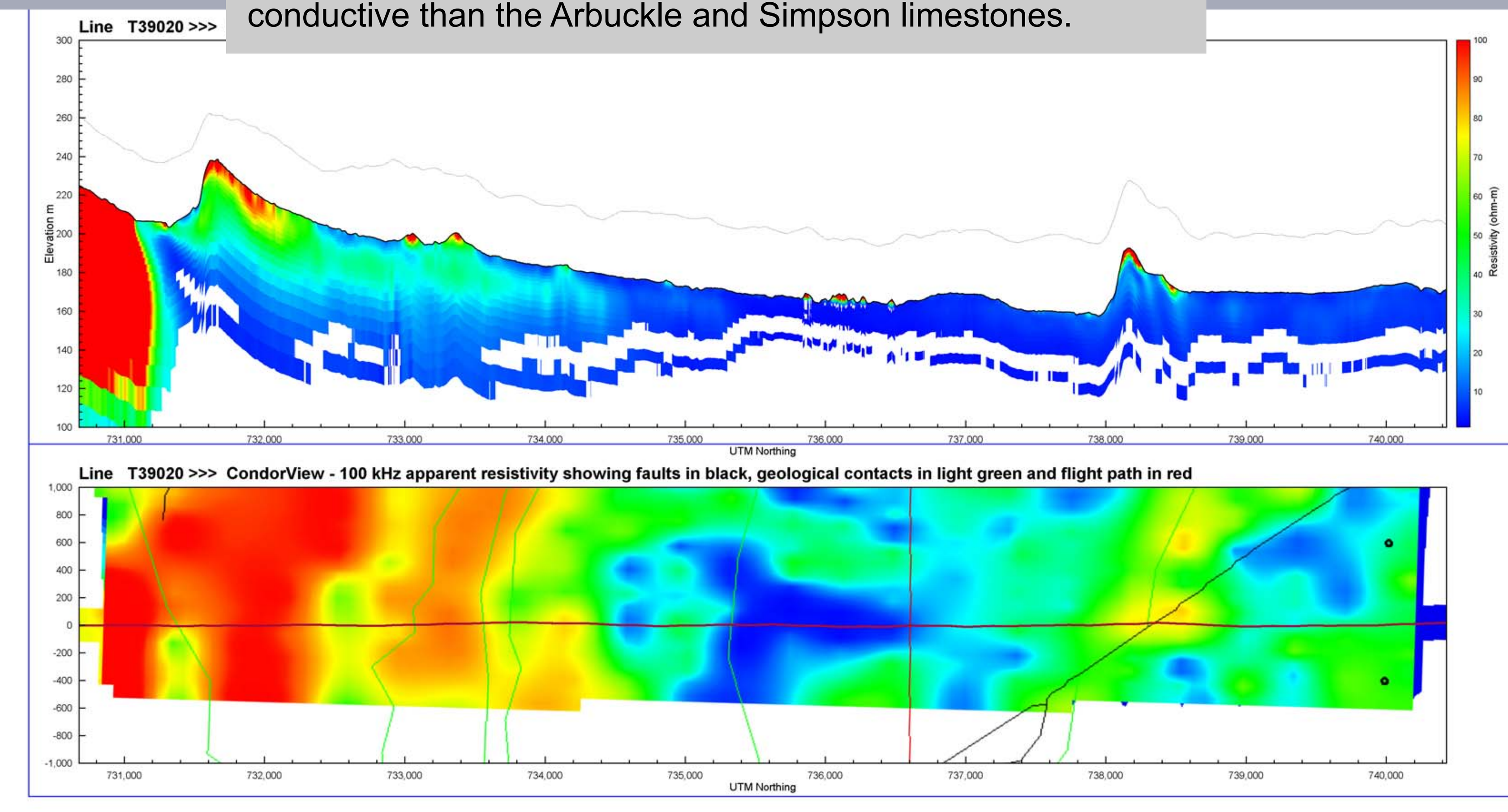
Block C Geophysics: Clarita Horst



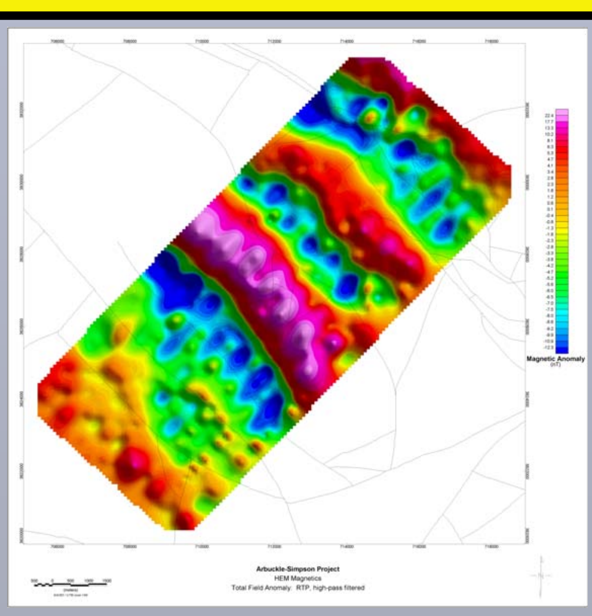
This map shows the total magnetic field after being microleveled, high pass filtered and reduced to the pole. The large positive magnetic field anomaly strikes roughly perpendicular to the exposed geology and probably represents a "basement " feature such as a structural flexure.



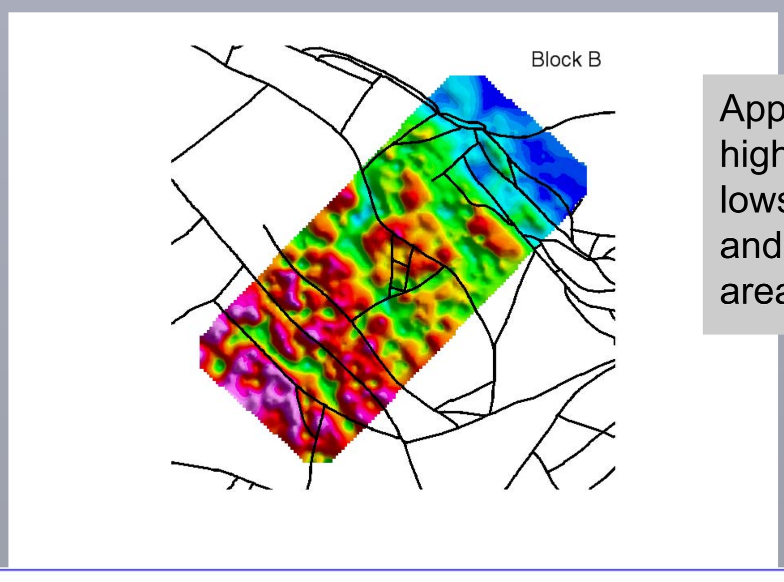
Apparent resistivity, above, at 115 kHz with highs (100 ohm-m) shown in warm colors and lows (10 ohm-m) in cool colors. The Paleozoic clastic rocks are almost an order of magnitude more conductive than the Arbuckle and Simpson limestones.



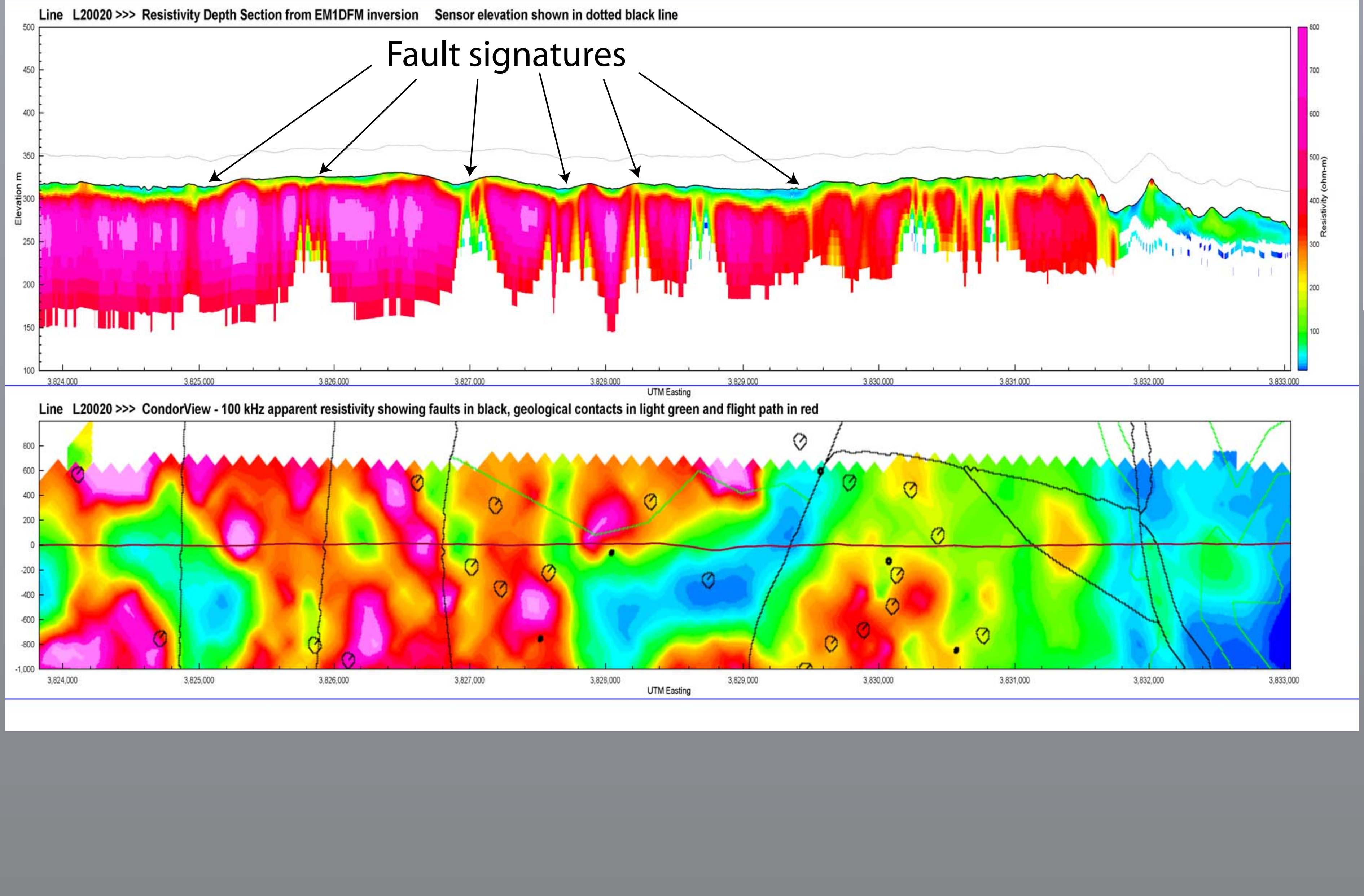
Block B Geophysics: Flank of Anticline



This map shows the total magnetic field anomaly after being microleveled, high pass filtered and reduced to the pole. The magnetic features follow the trends of mapped geologic units (black lines) and can be attributed to the near surface geology. The data do not reveal any magnetic expression of faults.



Apparent resistivity, above, at 115 kHz with highs (1,000 ohm-m) shown in warm colors and lows (10 ohm-m) in cool colors. The Arbuckle and Simpson limestones have low resistivity areas associated with faults and epikarst.



Resistivity depth sections shown above and to the left have been computed using the University of British Columbia EM1DFM imaging program. Depth of investigation has been estimated by differencing depth sections computed from 10 and 100 ohm-m starting models. The white areas in the more conductive parts of the section are due to a conservative cut-off in the differencing. In the horst, above, Paleozoic clastics appear to be separable based on the resistivity, which will aid geologic mapping. In Block B, the Arbuckle appears to be generally more resistive than the Simpson. The structures within the limestones are associated with varing levels of low resistivity. The surface low resistivity can be correlated in places with epikarst.