CASE STUDY

SURFACE CASING VENT FLOW & GAS MIGRATION

Well History

The subject well was horizontally drilled in the Bellis field of eastern Alberta in September of 2021. Surface casing was set at 244 m and cemented full length using a 1700 kg/m^3 cement blend which was designed to lower equivalent circulating density and prevent gas migration. Production casing was set at 819 m and 90 degrees inclination, then cemented full length using a 1550 kg/m3 cement blend designed to ensure hydraulic isolation between porous intervals throughout the wellbore. Four horizontal legs were drilled in the Lower Cretaceous heavy oil-bearing Sparky formation and completed open hole. The well was turned onto production with a progressive cavity pump in October 2021 and was discovered to have an active surface casing vent flow / sustained surface casing pressure. Gas migration testing was performed on lease on October 28th, 2021, and in-soil gas was discovered around the outer casing string. The operator reported the well integrity conditions to the Alberta Energy Regulator which initiated a 90-day period in which a repair attempt was required.

Intervention Summary

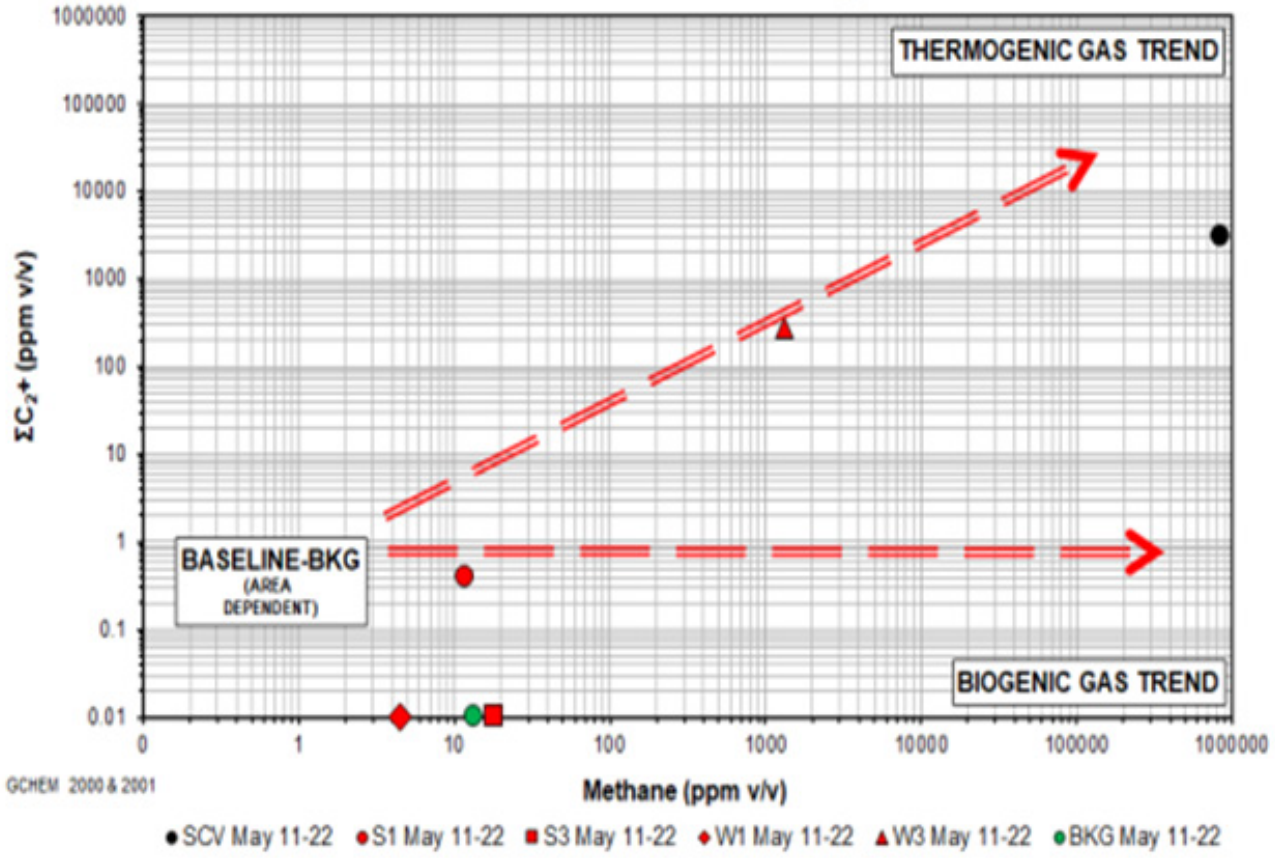
360 ELM was contracted to diagnosis and repair the wellbore integrity issues. The sucker rods and production tubing were pulled from the wellbore and a wireline retrievable plug was set at 593.9 mKB to protect the producing zone during remedial operations. A fibre-optic cable deployed high-fidelity noise/temperature log, radial cement bond log and cased hole analysis tool (CHAT) log were obtained from the well. The results of the obtained logs indicated two potential sources of annular gas – one from below plug back depth and one from the Colorado formation within the Upper Cretaceous group with formation top at 280 mKB. In-soil gas and surface casing gas were collected and analysis for composition, it was determined that the gases were thermogenic in origin and originating from the same source within the Colorado formation.

Due to the inability to correlate lower wellbore gas to surface flow, a shale seam at 280.0 mKB was selected to perform an intervention. The wellbore was perforated from 279.0 – 281.0 mKB in two separate runs using 2.0 m x 101.6 mm ERHSC 17 SPM 50-degree phased perforation guns fitted with Owen 25-gram GH charges in clockwise and counter-clockwise spiral rotation. The perforations were then acidized using 2 m3 of synthetic organic acid blend containing an alcohol-based surfactant and 3 MPa applied pressure was left on the production casing overnight. With only a slight bleed off down to 2.6 MPa overnight, the wellbore was swabbed dry to initiate flow and connectivity to the source of gas. The attempt to initiate flow was unsuccessful and a second attempt at a feed rate was made to 3 MPa, which again, bled down to 2.7 MPa. The perforations were acidized again using 15% HCL and 3 MPa applied pressure was left on the annulus overnight. The production casing pressure bled down to 1 MPa indicating an improved feed rate, and a bradenhead cement job was performed using a 1901 kg/m^3 class “G” 0-1-0 cement blend. The 72 m cement plug was placed from 5 meters below the remedial perforations and pressure was applied from surface flatlining at 2.8 MPa.

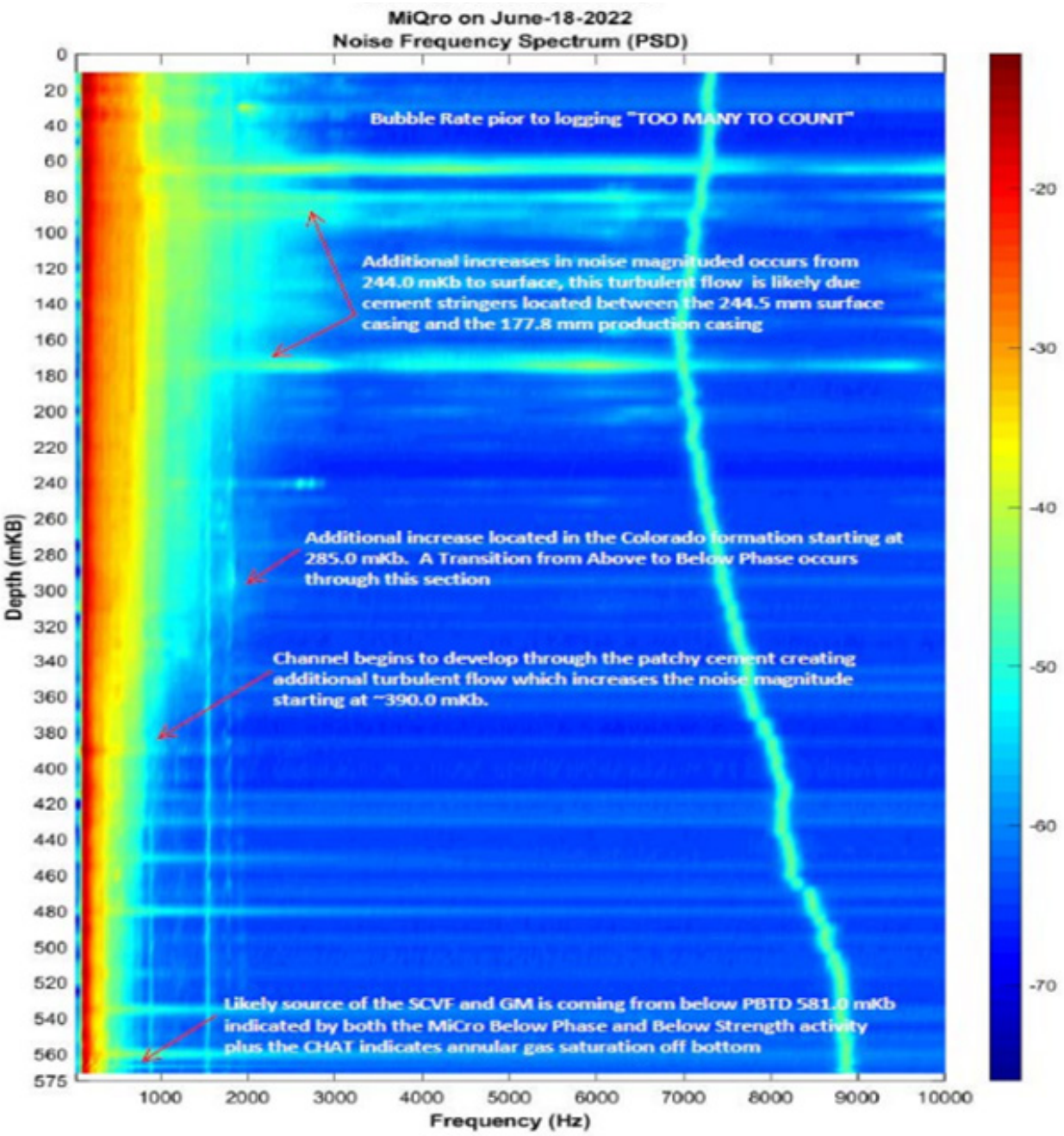
After the cement had sufficient time to cure, the cement plug was milled out and the wellbore was pressure tested to 7,000 kPa. The pressure test failed, but the stabilized shut-in surface casing vent pressure had reduced from 450 kPa to 146 kPa. A second cement job was performed on the same interval using a 1650 kg/m^3 micro fine cement blend extending from 5 m below the perforations to 48 m above. A bradenhead squeeze was applied to the cement plug to a flat-line pressure of 8 MPa.

After the cement plug had sufficient time to cure, the cement plug was drilled out and the wellbore was pressure tested to 7,000 kPa. The wellbore passed the pressure test and the shut in surface casing had decreased from 146 kPa to 76 kPa. Upon allowing the annular gas to dissipate, the surface casing vent flow was eliminated, and the well was returned to production.

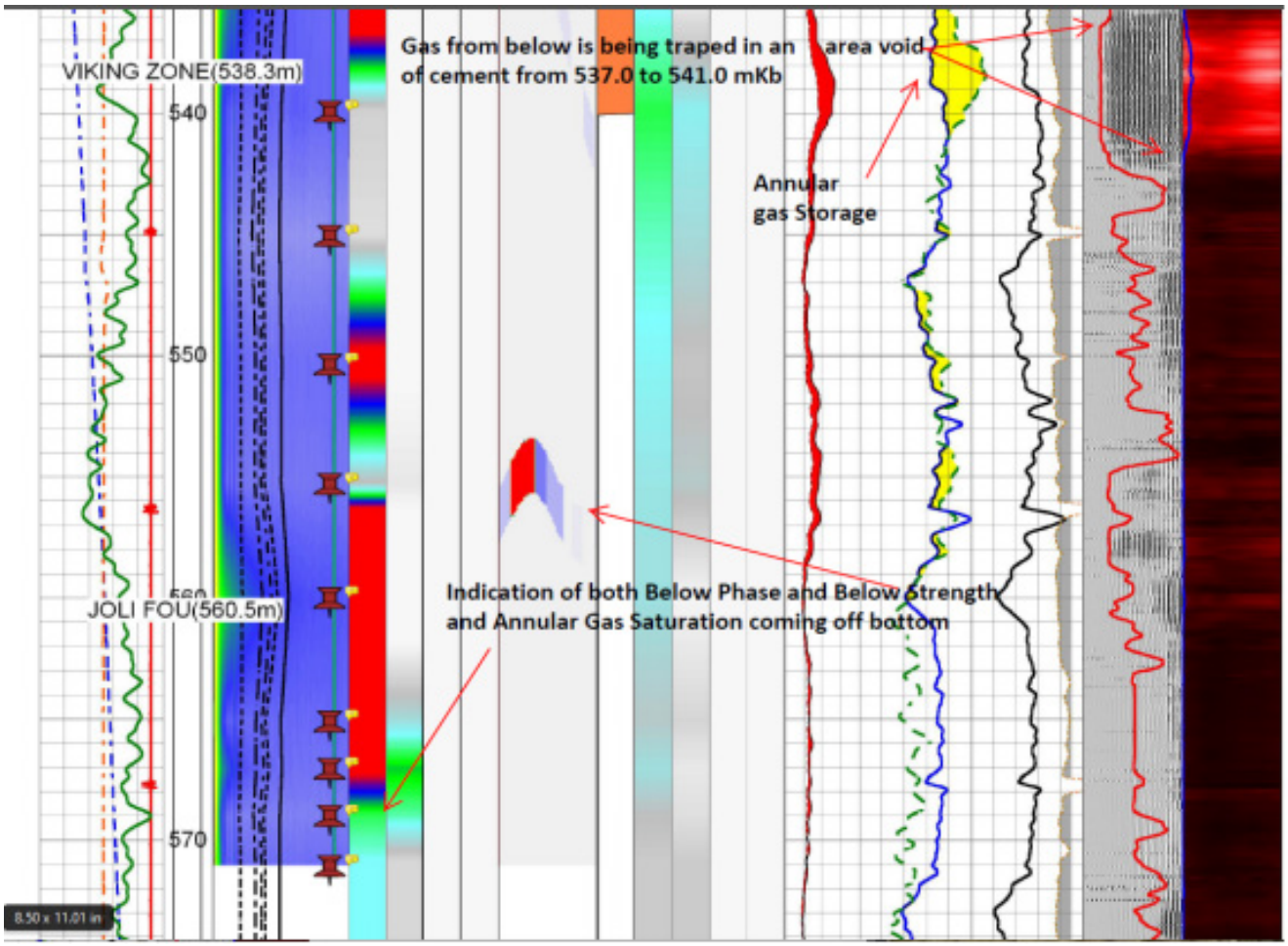
Carbon Isotope Analysis



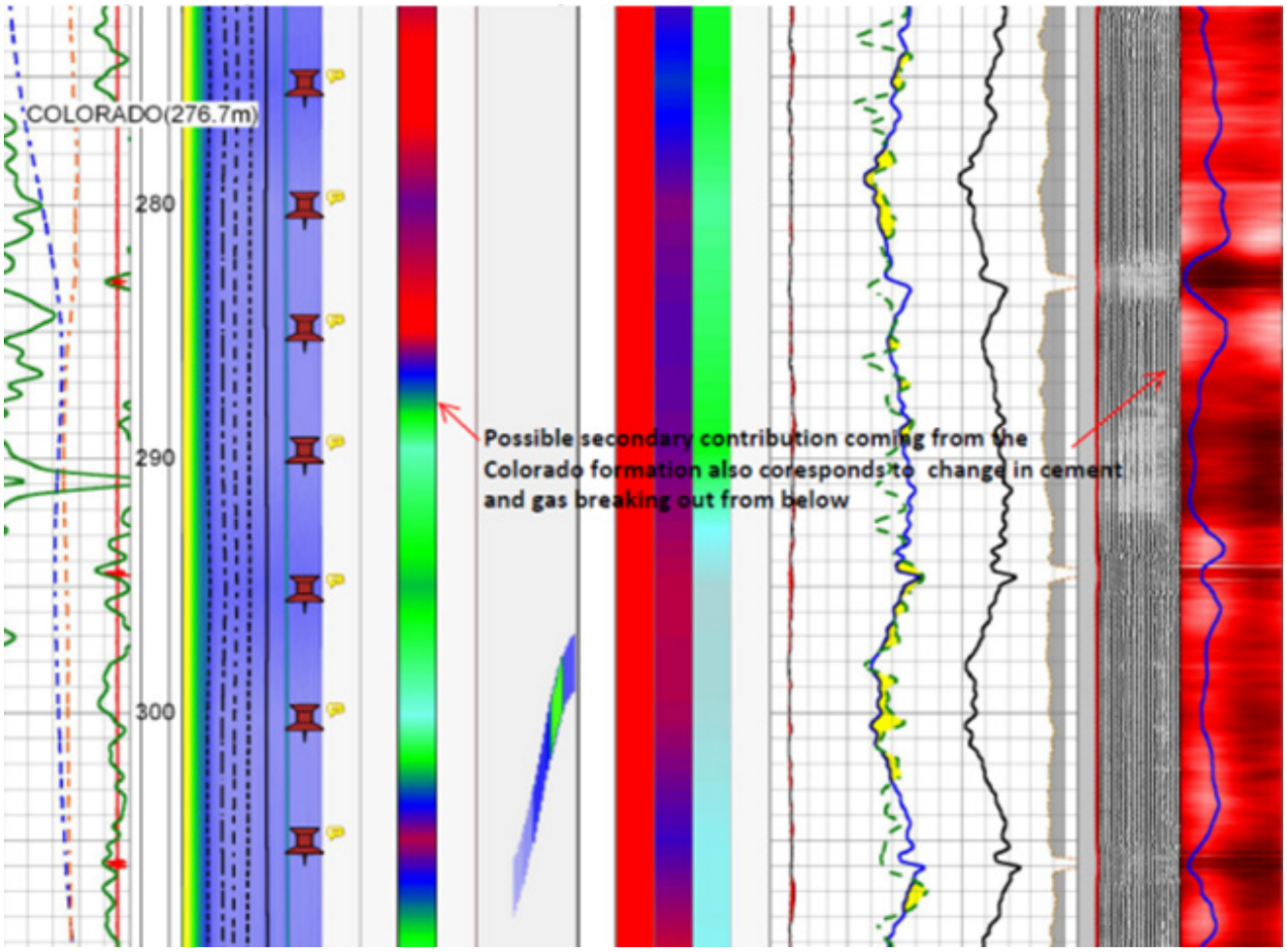
Frequency Spectrum Plot



AOI - Off Botton



AOI - Colorado Formation



Cement Chart