



Lessons learned from flow-back frac water composition on rock-fluid interaction in the Montney shale

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Summary

A water flowback analysis of many wells in the Montney from the Altares Field has clearly outlined local precipitation of barium sulfate as a result of the injected water from a reaction creating sulfate from sulfide. A depth profile of all of the water data collected clearly demonstrate that in the dry gas domain, water is absorbed by the clays. Water flowback analysis can also clearly identify interference between wells

Introduction

Extensive sampling of flowback water through time has been performed in the Altares Field, in NE British Columbia. The analysis performed on the data has brought to light new facts and understanding on the interaction between injected water and the rocks penetrated.

Theory and/or Method

Water injected during hydraulic fracturation may interact with lithologies encountered.

Sulfate precipitation: Frac water interacts with some of the sulfides present in the pore network; XRD analysis seems to indicate that the reacting mineral is marcasite. From the thin section analysis of the zones with sulfate precipitation, the marcasite has been found to be associated with hydrothermal minerals such as saddle dolomite, barite and sphalerite.

Shale dehydration: Evidence of shale dehydration have emerged when higher gas rates and lower volumes of flow-back water were recovered in wells where flow-back had to be delayed for operational reasons. The proposed mechanism relates to water being absorbed by the desiccated clays in the dry gas domain at a vitrinite reflectance value above or equal to 1.5%Ro. Similar observations were made in various shales of various North American basins. Our analysis of many wells in the Montney of the Altares field with flow back water compositions through time strongly support the proposed hypothesis above mentioned.

Additionally some isotope studies indicated that the hydrogen from the methane in the dry gas domain has two different signatures, one of which is not in line with the isotope from hydrocarbon molecule; it is thus deducted that some of the hydrogen of these methane molecules originally belonged to water molecules that have been broken down.

Some oxygen is expected to be left behind by the process of creating methane from ethane, propane or from larger molecules. This liberated oxygen could sometimes oxydize the organic matter as seen by the oxydized vitrinite in the dry gas domain (Chatellier et al. 2013)

The direct link between isotope reversal and overpressure in the dry gas domain is explained by the replacement of one molecule of ethane (or one of propane) by two (or three) molecules of methane, the latter occupying a larger volume than the original molecule. This gas volume increase being responsible for the observed overpressure in the dry gas domain.

Examples

Montney flow-back waters recovered from 79 of the stimulated wells have been extensively sampled in the Altares Field in British Columbia. The analysis has shed some light on sulfate precipitation in the Upper Montney of some wells and on dehydration of the clays in the dry gas domain, mostly confined to the Lower Montney in the Altares Field.

Quality control of the obtained data was done using plots of Na vs Cl through time; all of the wells showed a well behaved linear relationship between these two ions. Chloride has thus been used as the reference to examine if sulfate may be precipitating in the reservoir. In Figure 1, for the same flow back data set from one well, one can see that barium does not exhibit a simple and linear trend through time. No or little barium was recovered in solution in the first seven samples; the following samples show a linear trend towards a normal ratio.

The slope marked in red represents a return towards a balanced state with little to no sulfate precipitation. Of more direct significance are barium trends made up by the early concentration measurements that indicate how much sulfate precipitation took place (Fig.2).

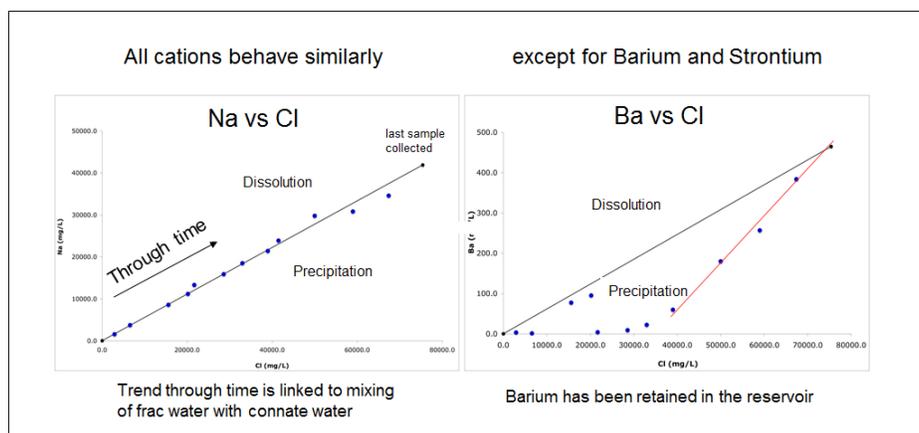


Fig. 1 Flowback water chemistry snapshot of procedure to identify sulfate precipitation

Slopes were calculated for all of the flowback water analyses. Only data that presented a linear fit with RSquared greater than 65% were retained for mapping. A 3-D analysis clearly demonstrated that a north-south fault was controlling the distribution of the barium sulfate precipitation (Fig.3).

Thin section and XRD analyses indicated that the sulfate precipitation was linked to the presence of marcasite found associated with saddle dolomite and sphalerite. The sulfide (here, marcasite) would have reacted with the injected water and created a sulfate; this process is reminiscent of what was observed in the Brent Field when the injected fresh water reacted with the framboidal pyrite of the Eive Formation creating a sulfate and producing H₂S in the process.

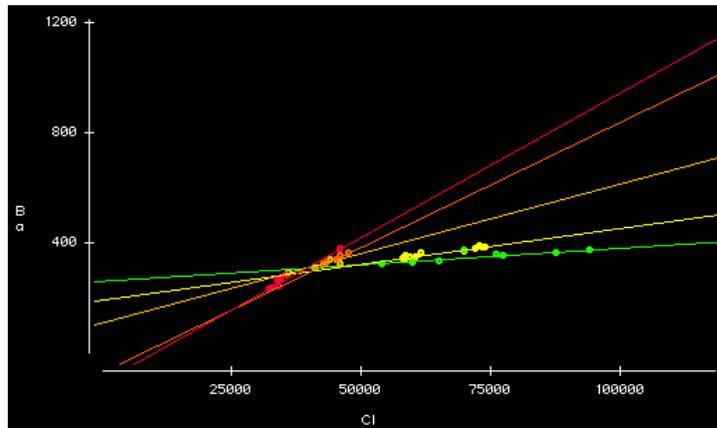


Fig.2 Examples of Ba vs Cl slopes extracted from early measurements in four well (flow-back waters)

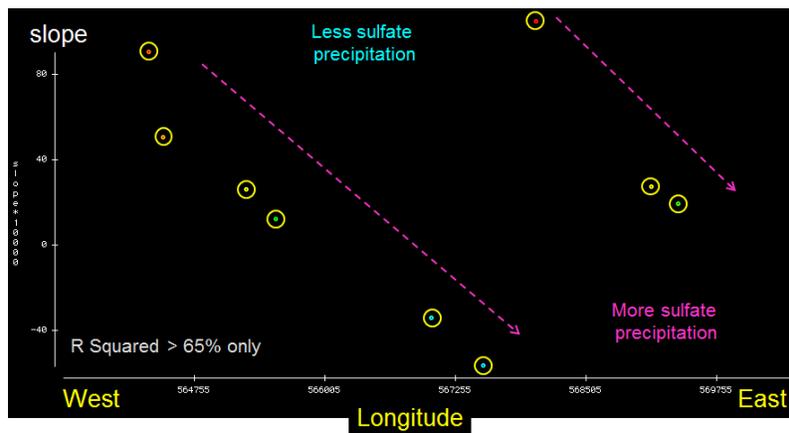


Fig.3 Two observed trends of sulfate precipitation after a north-south projection onto a W-E cross-section

Composition of the flowback water gradually gets saltier with time as expected, trending towards formation water composition (Fig.1). The Montney in the Altares field is some 400 meter thick and covers a large range of maturity, from wet gas to dry gas; the boundary between the two domains being around 2400m.

The intensive data collection campaign gave an ideal data set that allowed us to substantiate the hypothesis of dehydration of clays in the dry gas domain. This is summarized in figure 4 where the wells have been displayed against TVD.

Above 2400m TVD, there is a normal increase of chloride content with depth as expected in a hybrid shale system. **Below 2400m TVD** the decreasing Chloride content with depth does not represent salinity because the same increasing trends are recognized in Ba, Mg, Ca and Li. The trends are linked to decreasing amounts of water available for osmosis with frac water.

These various trends of decreasing concentration with depth are the expression of shale dehydration in the dry gas domain where secondary gas cracking takes place. In this process, **hydrogen from water is needed to create methane from ethane or from propane:**

($C_2H_6 + 2H \rightarrow 2 CH_4$ or $C_3H_8 + 4H \rightarrow 3 CH_4$).

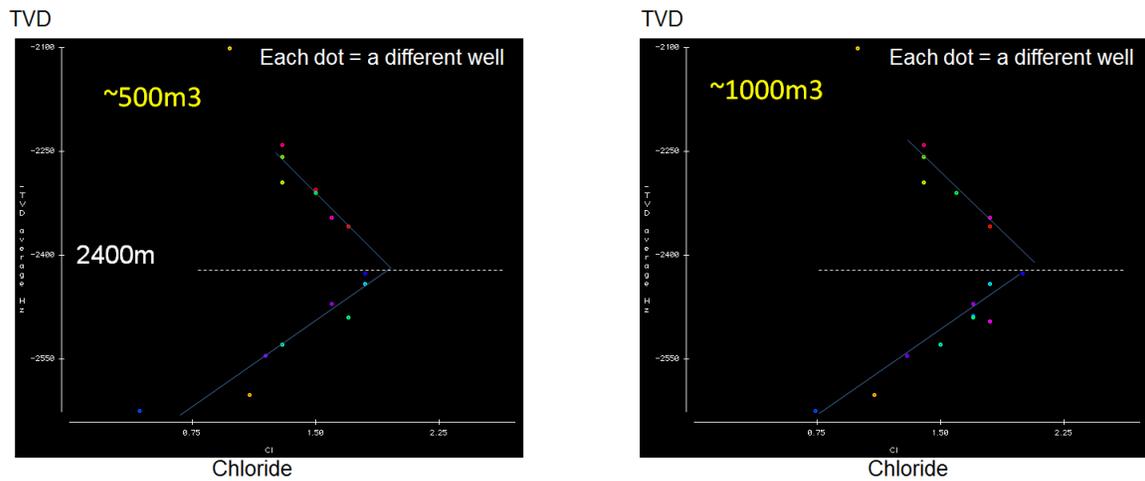
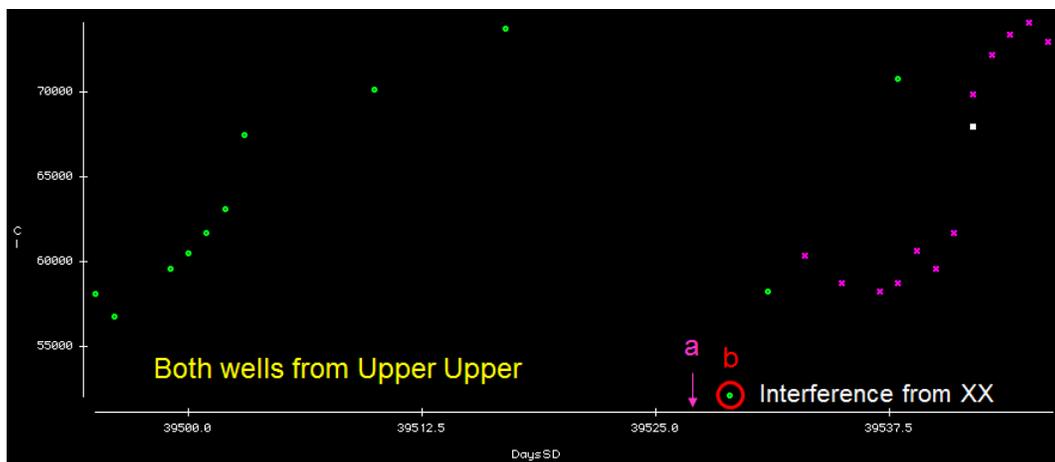


Fig.4 Geochemical profile of flowback water for some equal recovered volumes

Additionally, flowback water analysis allows to identify well interference as seen in Figure 5 where the composition of late flowback in one well is in perfect alignment with a neighboring well fracked later.



First well in green, second well (XX) in purple, "a" is frac date of second well

Fig.5 Example of nterference from nearby hydraulic fracturing

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