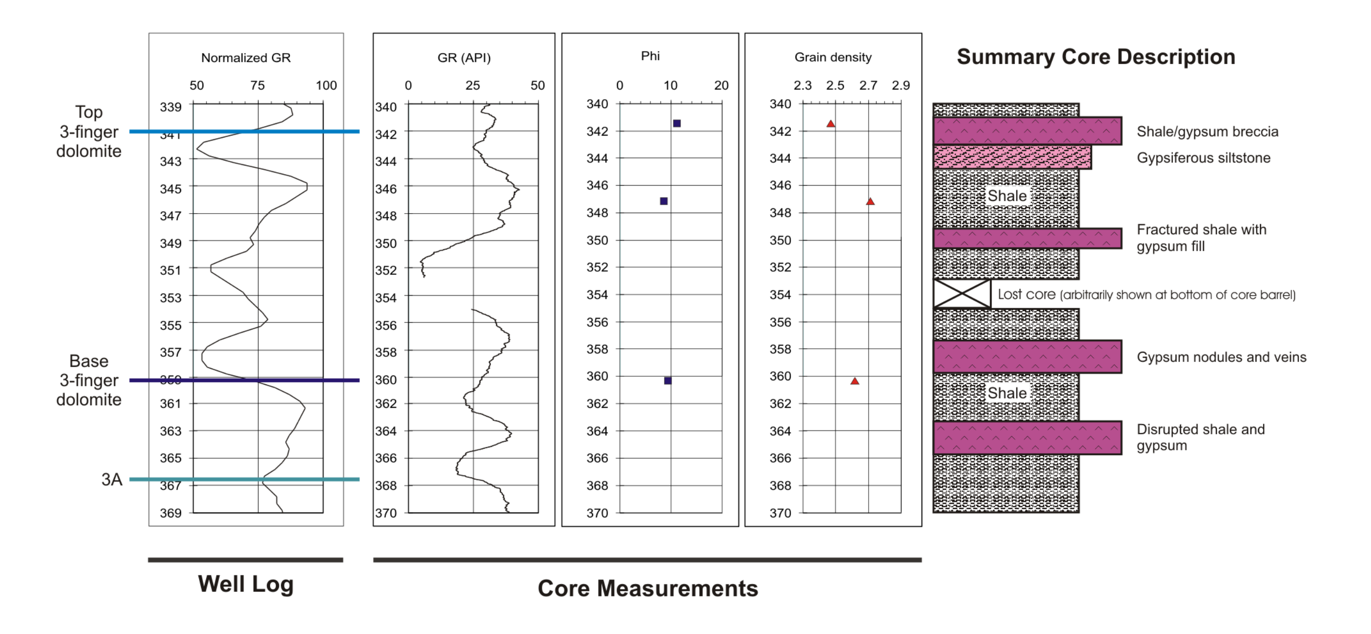
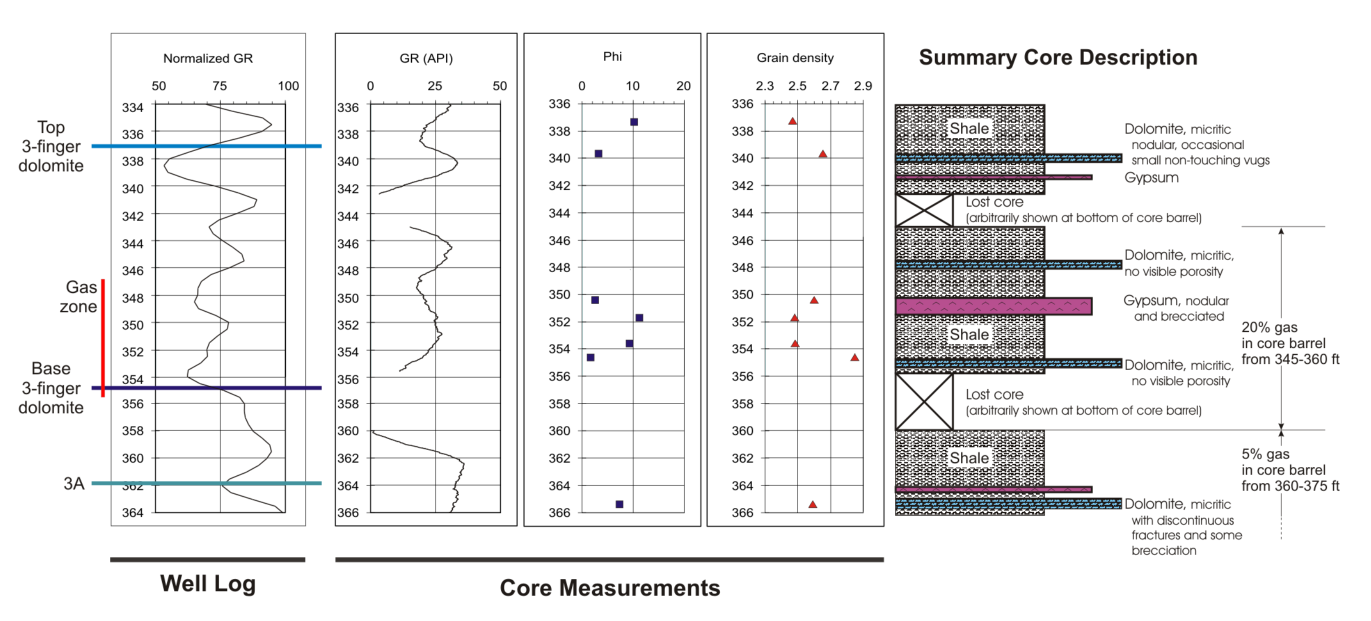
LITHOLOGY OF GAS-BEARING INTERVAL

DDV #63 Core Analysis



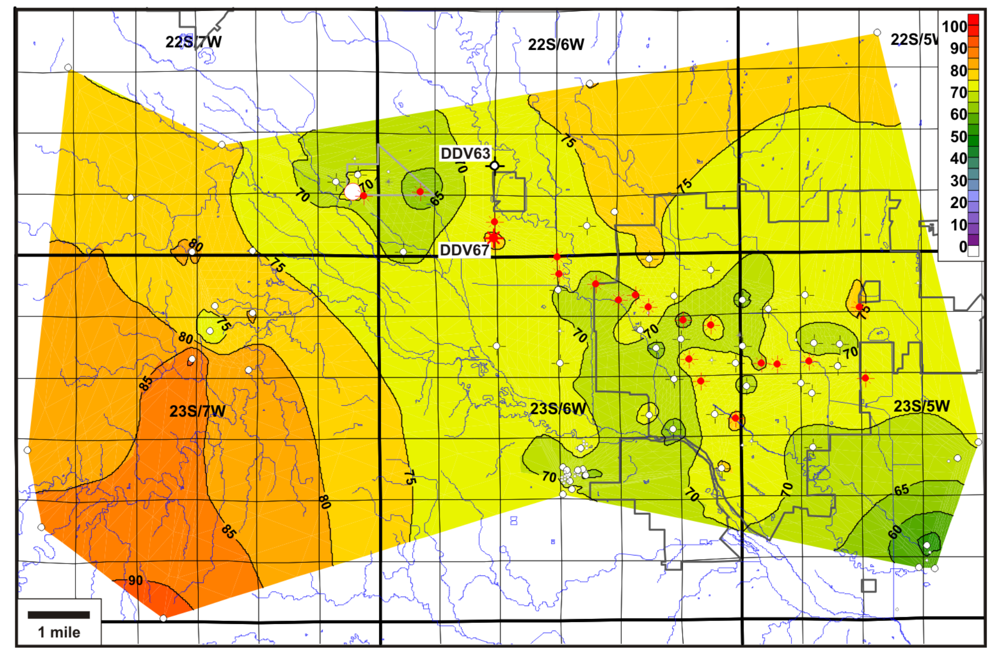
DDV #67 Core Analysis



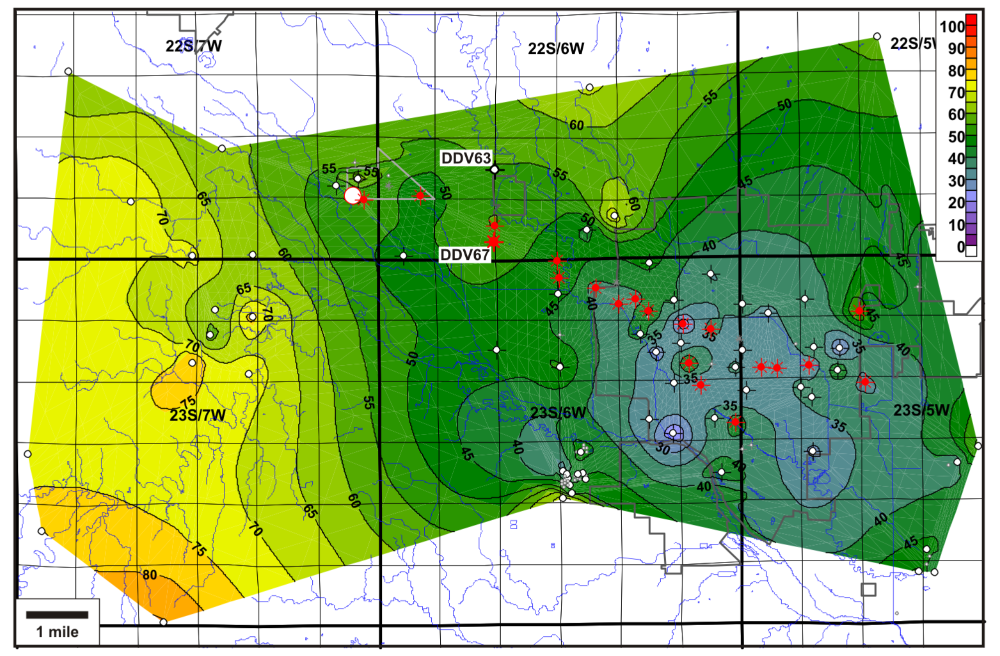
In March 2001, core was acquired at two locations along the Wilson Road seismic line to the west of Hutchinson: DDV #63 (dry hole) and DDV #67 (gas). DDV #67 was located approximately 75 ft from DDV #53, which was actively venting a high volume of gas. In the DDV #67 core, the gas-bearing 3-finger dolomite corresponds to a series of thin dolomite and gypsum layers, separated by shales. The dolomites in DDV #67 have low matrix porosity, suggesting that fractures controlled gas migration within this interval. The 3-finger interval is observed in dry hole DDV #63, but the core from this well shows that the interval is more shaly and gypsiferous than in gas well DDV #67.

Because dolomite is brittle and fracture-prone in contrast to shale and evaporites, which are in general more ductile, dolomite is likely to undergo induced fracturing and be able to maintain open fractures when subjected to high-pressure gas that exceeds the fracture pore pressure of the dolomite. An increase in the amount of gypsum and shale, both less brittle than dolomite, would tend to inhibit fracturing and prevent migration of gas.

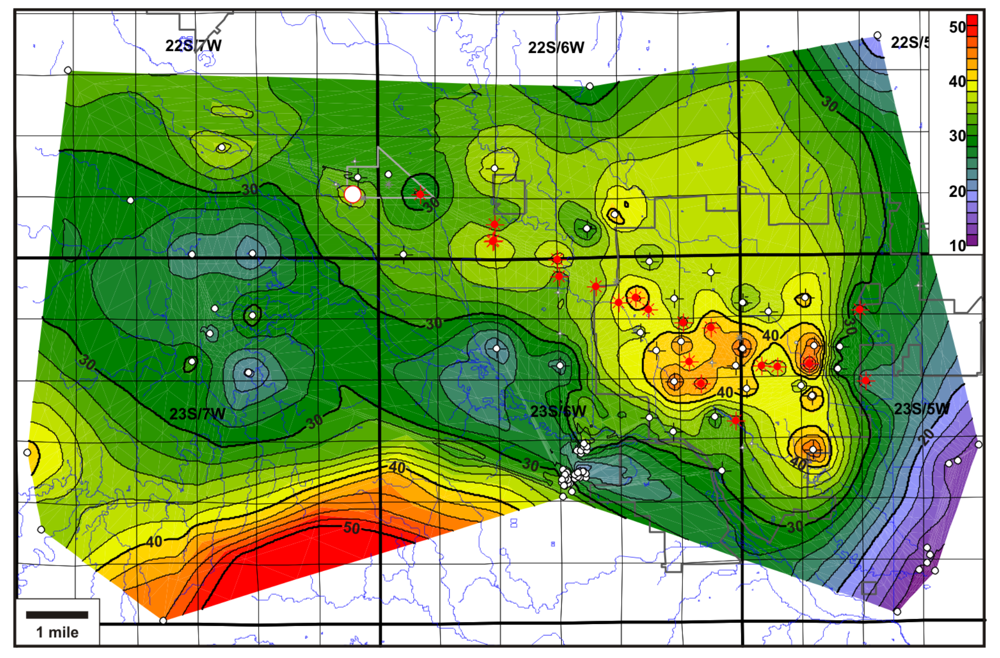
Mean Normalized Gamma



Minimum Normalized Gamma



S2 - S1 Isopach



Natural gamma ray serves as an indicator of lithology when substantiated with nearby core or outcrops. The gamma-ray logs in the Hutchinson-Yaggy study area were normalized to vary from 0 (salt) to 100 (shale), and variations in lithology of the 3-finger dolomite interval were investigated by looking at maps of mean normalized gamma ray and minimum normalized gamma ray.

Mean gamma shows the average shaliness of the interval and indicates that, in general, the 3-finger dolomite is cleanest along a northwest-southeast-trending corridor from Yaggy to Hutchinson, including the city proper, with considerable increase in shaliness to the southwest and minor increase in shaliness to the northeast.

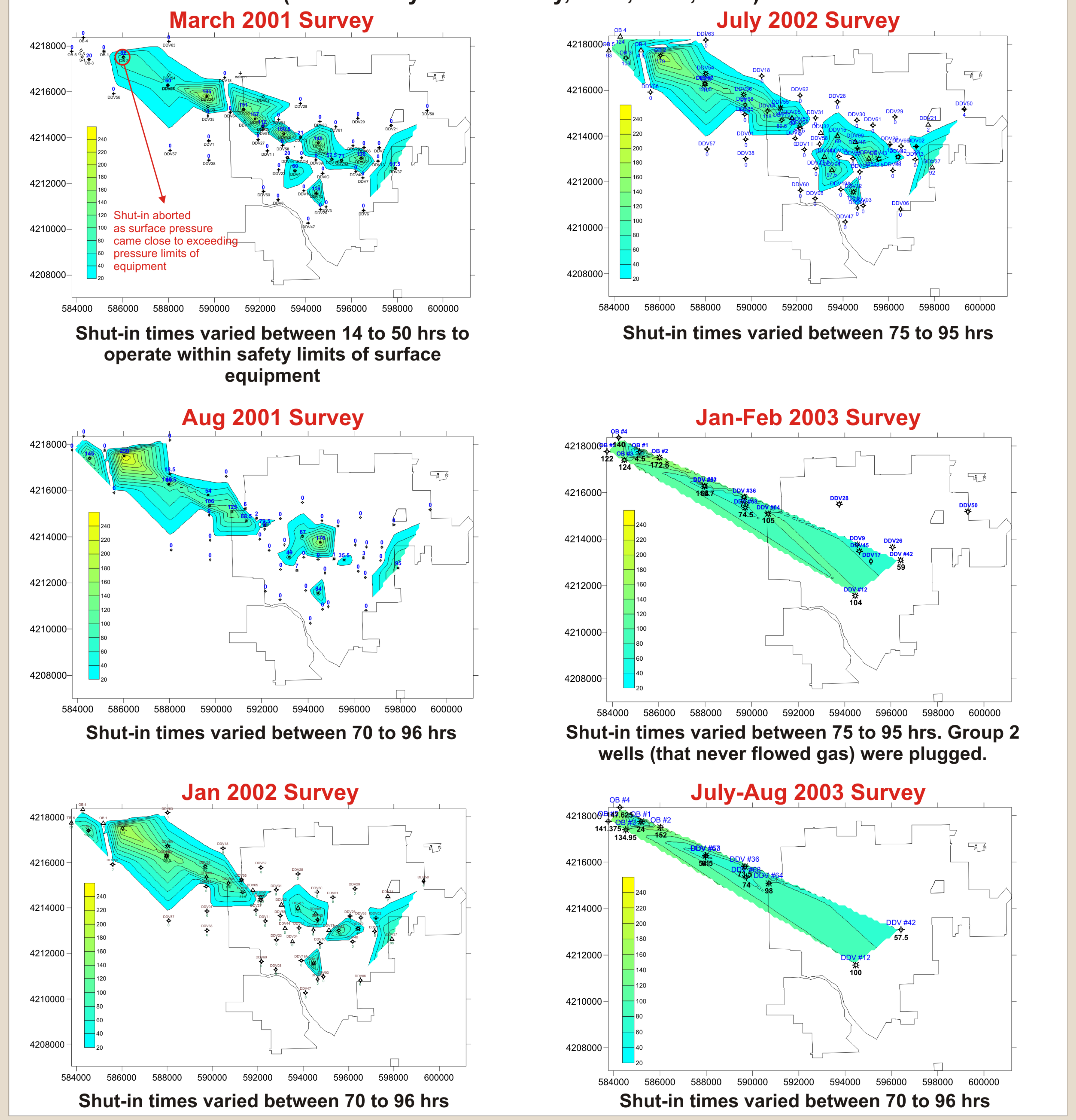
Minimum gamma, which identifies the shaliness of the cleanest dolomite within the interval (the top dolomite in all but a few wells), shows an even more dramatic decrease beneath Hutchinson and along the corridor northwest of the city toward Yaggy. The areas of lowest gamma ray in the 3-finger dolomite within and near the city are deemed more susceptible to fracturing and possibly have existing natural fractures that could serve as gas conduits, because the parting pressures of these fractures could be considerably lower than the pressure needed to create new fractures.

The location of the cleanest dolomite in the minimum gamma map of the 3-finger interval corresponds closely to a location of thick salt in the S2-S1 isopach map, suggesting that this area of preserved salt was a slight topographic high during the time of deposition of the 3-finger dolomite. This shallowing may have led to decreased turbidity and encouraged greater carbonate productivity.

RESULTS OF SUBSURFACE SHUT-IN ANALYSES

Calculated shut-in pressures (psi) at 3-finger dolomite

(Bhattacharya and Watney, 2001, 2002, 2003)



March 2001 Survey: Shut-in times varied between 14 to 50 hrs to operate within safety limits of surface equipment

July 2002 Survey: Shut-in times varied between 75 to 95 hrs

Aug 2001 Survey: Shut-in times varied between 70 to 96 hrs

Jan-Feb 2003 Survey: Shut-in times varied between 75 to 95 hrs. Group 2 wells (that never flowed gas) were plugged.

Jan 2002 Survey: Shut-in times varied between 70 to 96 hrs

July-Aug 2003 Survey: Shut-in times varied between 70 to 96 hrs

Vent wells have enabled controlled release of subsurface pressure over most of the affected area. In general, higher surface shut-in pressures have been noted closer to Yaggy and along the crest of the Yaggy-Hutchinson anticline. Current flow rates and shut-in pressures indicate that limited volumes of gas are venting from the remaining wells. Areas of the subsurface continue to be pressurized, though sub-hydrostatically, along the crest of the anticline; thus, select wells have been kept open for continued monitoring. The present slow decline in subsurface pressures associated with negligible gas flow at vent wells suggests reduced permeabilities and loss of apparent connectivity. This is consistent with a fracture model where, with reduced gas pressure, fracture apertures are reduced and closed due to decreased pore pressure.

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- GeoPLUS Corporation for access to the *PETRA*® well-log correlation and mapping software

CONCLUSIONS

- The gas that caused the January 2001 explosions in Hutchinson, Kansas, primarily moved laterally within a 20-30-ft-thick interval, which is composed of several thin dolomite layers, approximately 170 ft above the Hutchinson Salt Member.
- The main gas-bearing interval can be correlated on gamma-ray logs throughout the Hutchinson area and shows a regional westerly structural dip, with a broad west-northwest-trending anticline (the Yaggy-Hutchinson anticline) superimposed.
- The uppermost occurrence of gas is in a slightly deeper stratigraphic interval in the northernmost vent wells and appears to step up to the south by approximately 20 ft along a northwest-trending line which corresponds to the edge of a zone of local dissolution of the upper Hutchinson Salt Member.
- Dissolution of the upper Hutchinson Salt Member in the study area occurs along two structural trends (northwest and north-northeast). This dissolution may have caused flexure and preferred zones of weakness in the overlying strata, providing pathways for gas migration.
- Deep-seated faults and fractures appear to have controlled salt dissolution.
- A combination of core and gamma ray log data indicates that the 3-finger dolomite interval is less shaly along a northwest-southeast-trending corridor between Yaggy and Hutchinson.
- Salt remnants, produced by surrounding dissolution, may have been topographic highs during the deposition of the 3-finger dolomite, leading to the production of cleaner carbonates over these remnants. The cleaner carbonates are more susceptible to fracturing and could be preferential gas conduits.
- Higher subsurface shut-in pressures have been noted in vent and observation wells closer to Yaggy and in a linear trend along the crest of the Yaggy-Hutchinson anticline.
- Current slow decline in subsurface pressure associated with negligible gas flow at the vent wells is consistent with a fracture-flow model where fracture apertures have closed with reduced gas pressure.

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