[PS]A New Insight on the Mechanism of Salt Wall Collapse in Northeastern Paradox Basin, Utah*

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Abstract

The northeastern Paradox basin is characterized by a series of salt cored anticlines (salt walls) trending NW-SE. The crestal areas of the salt cored anticlines are breached and cut by faults. In the core of the salt walls, valleys are created by subsidence of the crestal overburden. There has always been a debate about the mechanism of the subsidence of the anticline crest. Some researchers, based on field observations favor the dissolution of the salt, as the main mechanism for the crestal subsidence. Others, based on physical modeling, favor a tectonic factor, with regional extension, as the main mechanism that triggered the subsidence. A 3D seismic dataset covering the northern end of Salt Valley Salt Wall in the northeastern part of the Paradox Basin presents a unique opportunity to investigate and provide a new perspective on the origin of the collapse structures. Interpretation of the seismic data shows a graben system that formed in the crestal area of the salt wall. The graben system has a maximum displacement at the NW end decreasing toward the central part of the salt wall toward the SE. The maximum displacement occurs where the salt crest is deepest and the minimum displacement, where the salt crest is highest. The data suggest the displacement of the graben system might be attributed to lateral salt migration within the salt wall. Salt migrates from where the overburden is thickest (higher pressure head) toward the central part of the salt wall where the overburden is thinnest (lower pressure head). However, extensional faults might help increase the groundwater circulation in the areas where the salt wall is closer to the surface. This might also enhance salt dissolution in those areas, which triggered the salt to flow from deeper levels and along the strike of the salt wall. Several 2D numerical forward models were performed to test the hypothesis of the internal salt migration. This preliminary work suggests that the mechanism for the formation of the salt valleys might be attributed to multiple factors (i.e., extensional forces, salt dissolution, and internal salt flow) rather than favoring a single mechanism for the formation of the salt valleys in the northeastern Paradox Basin. The findings of this work might also be applied to other fault systems that exist at the end of the salt structures in the Paradox Basin (e.g., Moab, Fisher Valley, and Castle Valley salt walls).

References Cited

Ge, H., M.P.A. Jackson, and B.C. Vendevilee, 1996, Extensional Origin of Breached Paradox Diapirs, Utah and Colorado: Field Observations and Scaled Physical Models, *in* A.C. Huffman, W.R. Lund, and L.H. Godwin (eds.), Geology and Resources of the Paradox Basin: Utah Geological Association Guidebook, v. 25, p. 285-293.

Trudgill, B.D., 2011, Evolution of Salt Structures in the Northern Paradox Basin: Controls on Evaporite Deposition, Salt Wall Growth and Suprasalt Stratigraphic Architecture: Basin Research, v. 23, p. 208-238.

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A New Insight on the Mechanism of Salt Wall Collapse in Northeastern Paradox Basin, Utah

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GEOLOGICAL SETTINGS

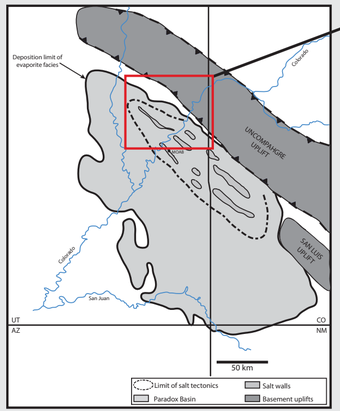

Figure 2. Regional map of the Paradox basin and associated Uncompahgre and San Luis uplift, showing the location of the salt wall structures, areal limit of salt tectonics and the depositional limit of evaporite facies (after Trudgill, 2011).

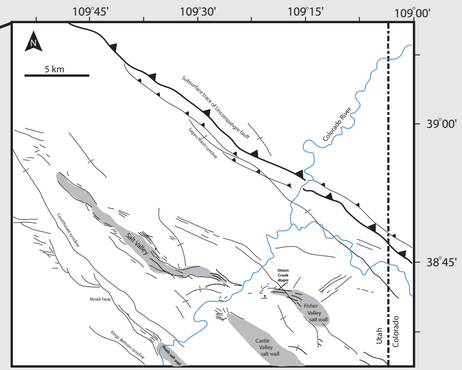

Figure 3. A structural map of the northern Paradox Basin illustrates the NW-SE regional trend of the salt wall structures and the major faults (after Trudgill, 2011).

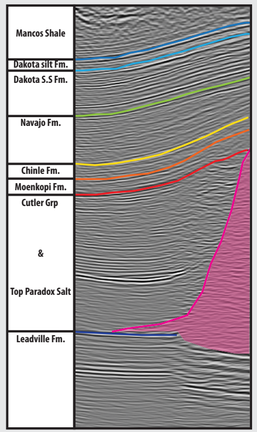

Figure 4. Stratigraphic column of units tops interpreted in the northern Salt Valley salt structure, northern Paradox Basin, showing the colors used in the seismic sections (after Trudgill, 2011).

SEISMIC INTERPRETATION

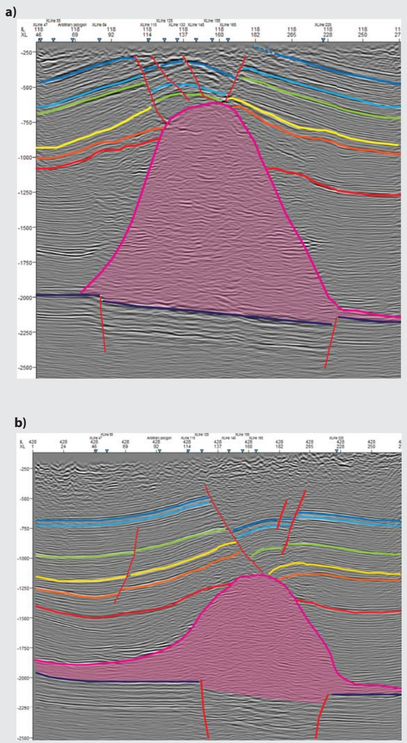

Figure 5. Time migrated seismic sections across the Salt Valley salt structure. (a) located to the southern side while (b) is located to the northern side. Notice the decrease of fault displacement toward the south of the seismic data and the increase in the salt wall height. Also notice the location of the salt weld. Salt weld located closer to the salt wall in areas to the south of the seismic area.

CRESTAL GRABEN

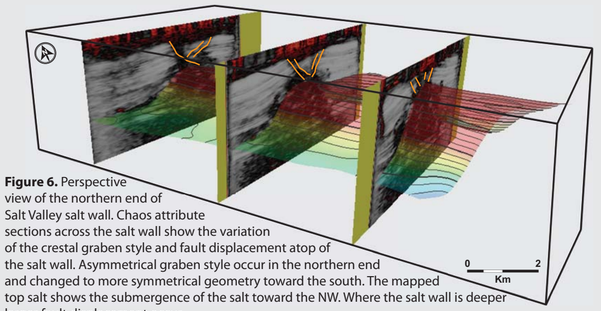

Figure 6. Perspective view of the northern end of Salt Valley salt wall. Chaos attribute sections across the salt wall show the variation of the crestal graben style and fault displacement atop of the salt wall. Asymmetrical graben style occur in the northern end and changed to more symmetrical geometry toward the south. The mapped top salt shows the submergence of the salt toward the NW. Where the salt wall is deeper larger fault displacement occur.

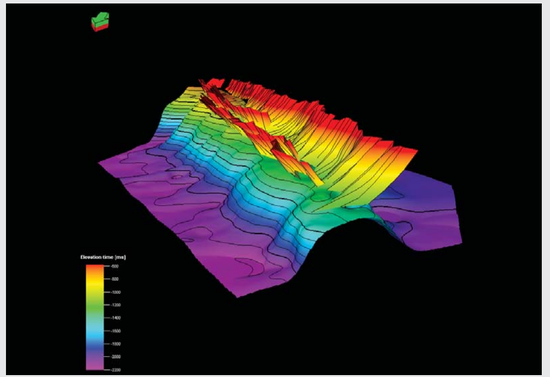

Figure 7. Structural map of the top Paradox formation in the Salt Valley salt wall. The salt wall is plunging toward the northwest. A graben system presents on the salt wall with decreasing ifaults displacement toward the southeast.
The migration of the Paradox Formation salt from the NW side of the salt wall toward the southeastern side of the salt wall controlled the formation of this graben system.

NUMERICAL FORWARD MODELING

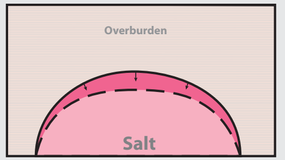

Figure 8. Model geometry designed in ELFEN. The solid line is the top salt in the initial stage. Dashed line is the final stage after salt was migrated/dissolved.

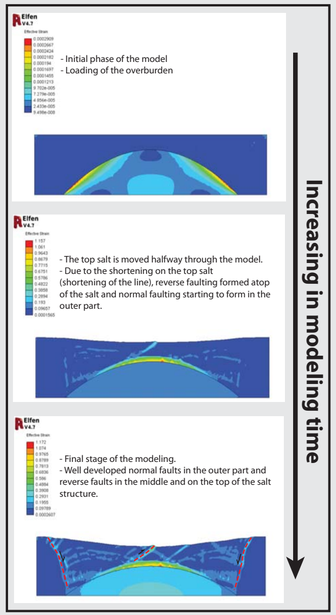

Figure 9. Three effective strain time lapes during the forward modeling time. As the initial top salt is moving through the model time toward the final position, normal faults formed in the outer part of the salt structure. Reverse fault form in the late stage of the model on the top of the salt.

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ABSTRACT

The northeastern Paradox basin is characterized by a series of salt cored anticlines (salt walls) trending NW-SE. The crestal areas of the salt cored anticlines are breached and cut by faults. In the core of the anticlines, valleys are created by the subsidence of the crestal overburden. Structural maps of the Paradox fold and fault belt show splay faults at the salt wall ends (e.g. Moab salt wall, salt valley and castle valley). There has always been a debate about the mechanism of the subsidence of the anticline crest. Some researchers based on field observations, favor the dissolution of the salt, forming the core of the anticlines, as the main mechanism for the crestal subsidence. Others, based on physical modeling, favor the tectonic factor, extensional forces, as the main mechanism that triggered the subsidence. A 3D seismic dataset covering the northern end of Salt Valley Salt Wall in the northeastern part of the Paradox Basin present a unique opportunity to investigate and provide a new perspective on the origin of the collapse structures. The interpretation of the seismic data shows a graben system that formed in the crestal area of the salt anticline. The graben system has a maximum displacement in the NW end and decreases toward the central part of the salt wall toward the SE. The maximum displacement occurs where the salt crest is deepest and the minimum displacement, where the salt crest is highest. The data suggest the displacement of the graben system might be attributed to salt migration within the salt wall. Salt migrates from where the overburden is thickest (higher pressure head) toward the central part of the salt wall where the overburden is thinnest (lower pressure head). However, extensional faults might help increase the groundwater circulation in the areas where the salt anticline is closer to the surface. This might also enhance salt dissolution in those areas which triggered the salt to flow from deeper parts and along the strike of the salt wall. Several 2D numerical forward models were performed to test the hypothesis of the internal salt migration. This preliminary work suggests that the mechanism for the formation of the salt valleys might be attributed to multiple factors (i.e. extensional forces, salt dissolution and internal salt flowage) rather than favoring a single mechanism for the formation of the salt valleys in the northeastern Paradox Basin. The findings of this work might also be applied to other fault systems that exist at the end of the salt structures in the Paradox Basin.

INTRODUCTION/MOTIVE

Salt collapse / diapr fall structure in the Paradox basin are attributed to be a result of either:

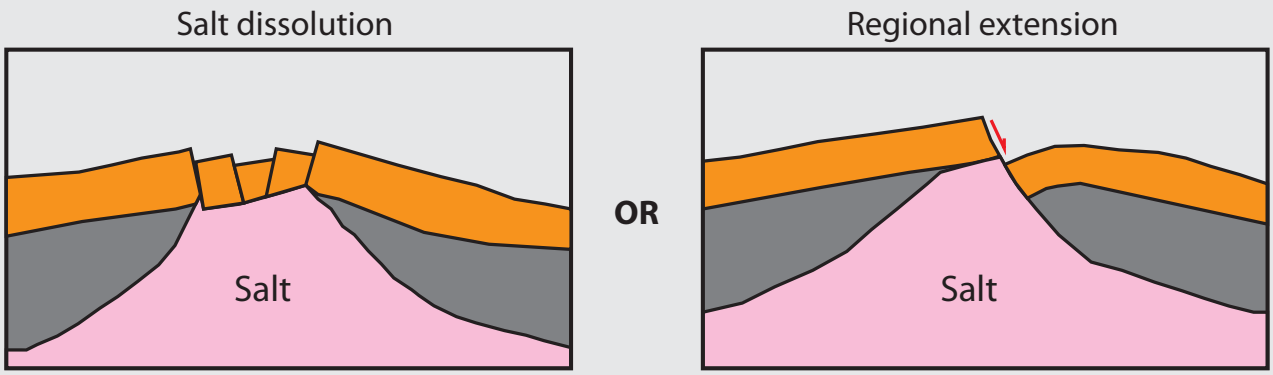

Figure1. Previous proposed models for diapir fall / salt collapse structure (after Ge et al., 1996)

GEOLOGICAL EVOLUTION MODEL

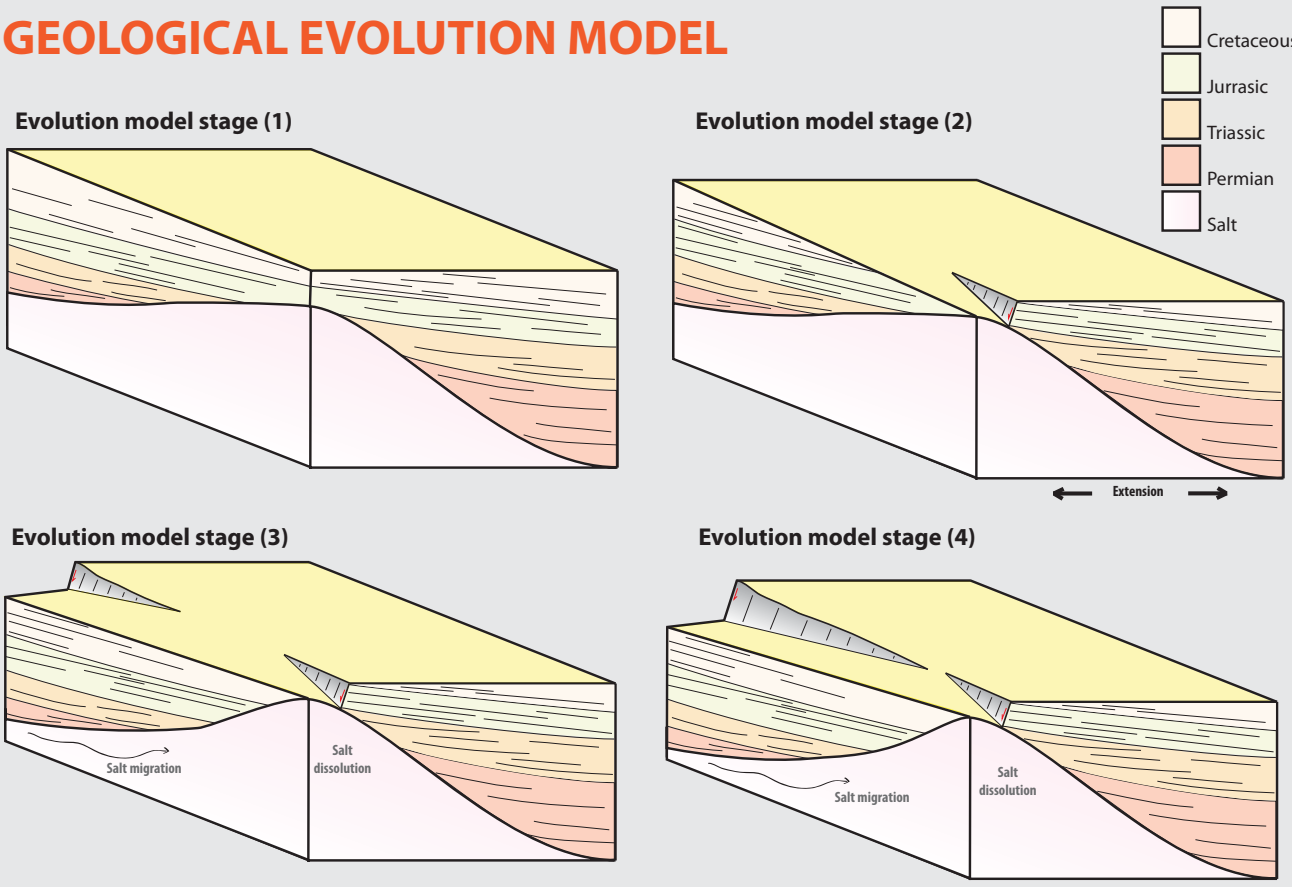

Figure 10. Evolution model of collapse structure in the northern end of Salt Valley Salt Structure, Utah. 1) Laramide compressional forces affected the salt structure and adjacent synclines folding the depositional sequences.2)Extension (local or/and regional) causing the thin crestal overburden to break forming crestal faults. 3)The crestal faulting facilitate the salt dissolution processes in the shallow areas of the salt wall along salt migration from the higher pressure head to lower pressure head. 4) The salt migration continues from deeper parts (higher pressure head) toward the shallower parts (lower pressure head) of the salt wall lead to the formation of crestal graben system with more slip and vertical displacement over the thick overburden.

CONCLUSIONS AND FUTURE WORK

- A well-developed graben system exists on top of the salt wall with decreasing fault displacement toward the south.
- The style of the graben system changes from assymetrical to more of a symmetrical system toward the south of the salt wall with different size and displacement.
- The current evolution models either favor the tectonic or dissolution models for the collapse structure.
- The evolution model in this study suggests the combination of the tectonic/local extension and the dissolution processes to cause the collapse structure.
- Tectonic/local extension breaks the thin overburden atop of the salt structure. This disturbance in the overburden will help the water to circulate and dissolve the salt. The dissolution along with the overburden faults will disturb the pressure system which will lead to the salt migration with the salt wall.
- Further forward modeling will be performed to test the validity of the proposed model.

REFERENCES

Ge, H., Jackson, M.P.A., Vendevilee, B.C., 1996. Extensional origin of breached Paradox Diapirs, Utah and Colorado: field observations and scaled physical models. In: Huffman, A.C., Lund, W.R., Godwin, L.H. (Eds.), Geology and Resources of the Paradox Basin. Utah Geological Association Guidebook, vol. 25, pp. 285– 293.

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