Feasibility Study of a salt diapiric structure for a gas storage in the north of Spain

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Abstract
In order to locate a suitable site for accommodating a natural gas storage in leached salt caverns ranging from 300 000 m^3 to 500 000 m^3, a multidisciplinary approach has been used including surface geology, gravimetry survey, wireline log study and reflection seismic (62 km). The aim of this paper is to present the methodology and outline its adequacy to cope with the objectives.

INTRODUCTION

The studied area is located in the north of Spain, characterized by the occurrence of many Keuper salt diapirs, initialized during the Cretaceous period.
The storage requiring a minimum salt depth of about 1000 metres, it will be necessary to delineate the underground geometry of the salt dome.

OUTCROPS

The geological map study allows a close location of the salt diapir, the caprock showing outcrops of Keuperian shaly gypsiferous facies associated with cellular dolomites and dolerites. It is surrounded by Miocene layers whose onlap dipping increases suddenly on the northern intrusion flank (subvertical dipping).

GRAVIMETRY DATA (figure 1)

The gravity map indicates a clear overall circular anomaly whose maximum of 6 milligals is slightly Northeast shifted suggesting a dissymmetrical extension of the salt structure.

WELL DATA (figures 2 and 3)

A well located at the Northeast of the structure down to a depth of 5300 metres has encountered 800 metres of massive halite interbedded with two dolerite layers. A sonic versus gamma ray cross-plot suggests a lack of insolubles (anhydrite and marls).

Triassic is overlaid unconformably by thick lower Cretaceous siliclastics (Albo-Cenomanian).

The Upper Cretaceous is constituted by Turonian limestones and Coniacian marls and tight limestones. This suggests a sudden paleo-environment change at the end of Cenomanian.

The seismic data indicate clearly high reflectivity contrasts between halite and dolerite as well as between Albian sandstones and shales and at the base of tight Coniacian limestones.

The outcrops with the measured dips have been plotted on the altimetry curve allowing a supplementary tying for Miocene layers.

SEISMIC INTERPRETATION (figures 4 and 5)

The quality of lines was excellent (Vibroseis, C 9000 %). The top and base of salt as well as the top of Coniacian limestones have been chosen. The combined interpretation of lines 05 and 06 indicates the occurrence of a saliferous overhang in the Miocene series. The seismic measured dips are in conformity with outcrops values. Triassic dolerite strong reflectors allow an accurate picking of the base of the structure.

The combined interpretation allows the understanding of the polyphasic saliferous tectonic in successive steps:

Initialization of a salt pillow during Albian followed by a latent period from Cenomanian up to Santonian confirmed by the parallel facies of limestone deposits. The major activity would be Miocene with perforation (salt plug) of Coniacian limestones, initialization of the Southern rim syncline and creation of a subcropping lateral overhang in the same direction. This explains the peculiar shape of the gravimetric anomaly, the maximal values uprighting the salt plug.

STRUCTURAL AND STORAGE FEASIBILITY CONCLUSIONS

Main geometric characteristics can be summarized as follows:

- The diapiric intrusion by itself (salt thickness of 5600 m) shows an extension of 5 x 2 km. In this area the top of salt below the caprock is localized at a depth of 300 m. This area is suitable for implantation of gas storage cavities.
- In the upper part of the intrusion, a salt overhang (area of preferential superficial lateral creeping of salt in the soft tertiary sediments), showing a thickness of 1 km and a width of 2 x 3 km, detectable but hardly interpretable on the gravimetry data but clearly visible on the reflection seismic data has been detected. This area is not suitable for salt cavities implantation. These phenomena can be compared with the intrusion of salt in compact tertiary limestones featuring a cylindrical plug feature.
- According to well data and tying of the seismic, thick dolerite layers of more than 150 metres thickness, characterized by strong reflection intensity at 6 km depth have been detected, which can be related to caprock outcrops facies suggesting a common rising with deep salt layers although their high density.
- The diapir rims are very steep with a sudden dissymmetrical unlevelling of 4500 m in the south and 3400 m in the north flank.

METHODOLOGICAL CONCLUSIONS

The integration of various approaches has allowed a close understanding of the geometrical design of the diapir and the most favourable location for the storage. The seismic reflection survey removed ambiguities on former gravimetry data interpretations relative to the shape of the anomaly, confirming the adequacy of the multidisciplinary methodology.

ACKNOWLEDGEMENTS

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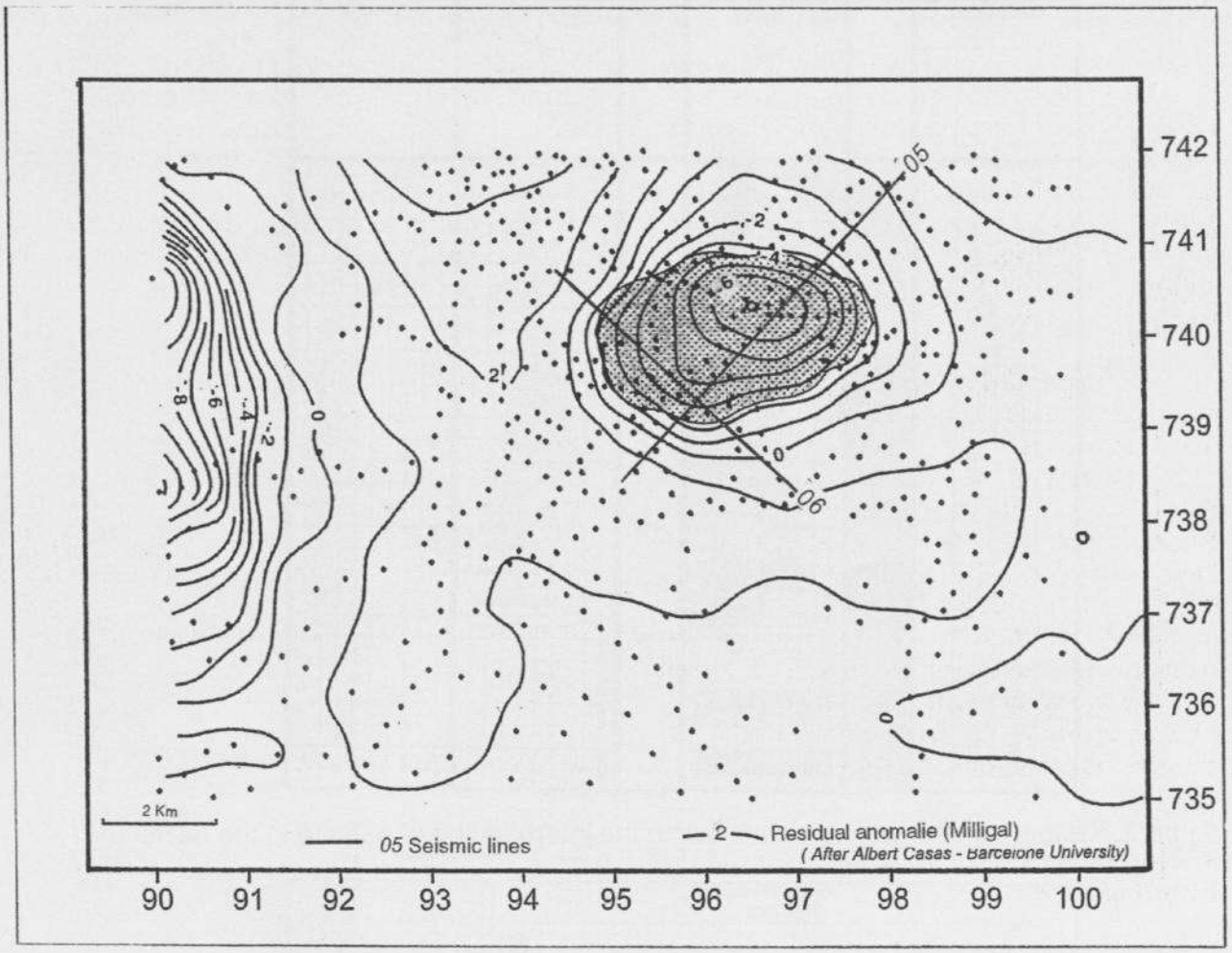

Figure 1. Gravity survey - residual anomalies map

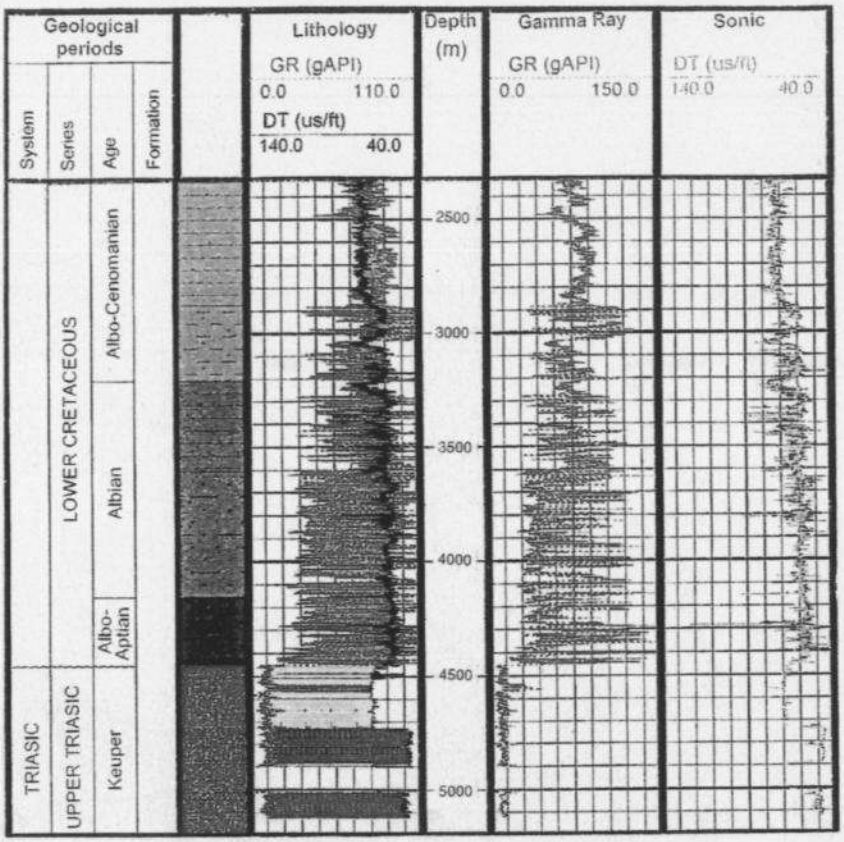

Figure 2. Keuper wireline logs facies showing the interbedding of dolerite in the halite

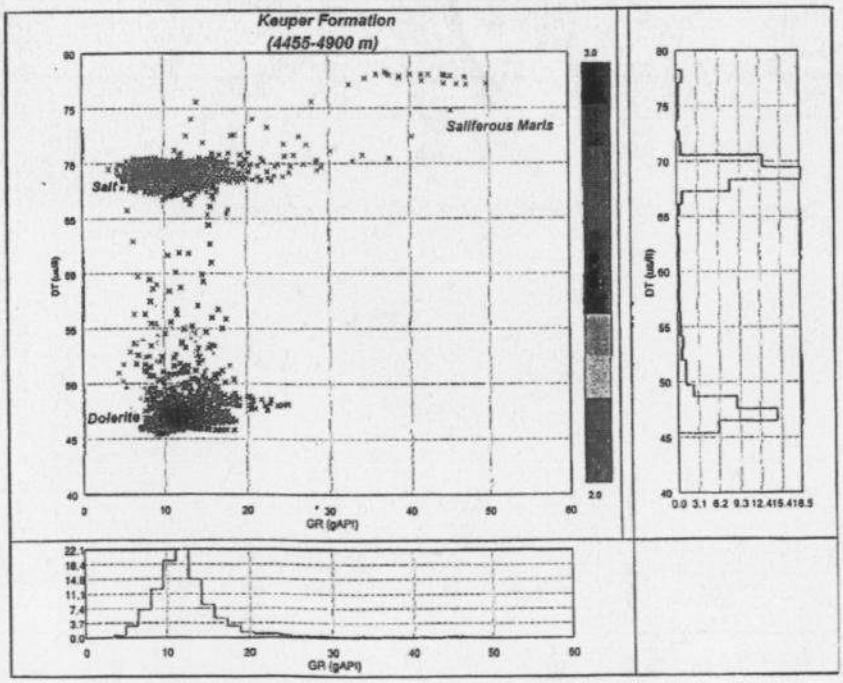

Figure 3. Sonic gamma ray plot

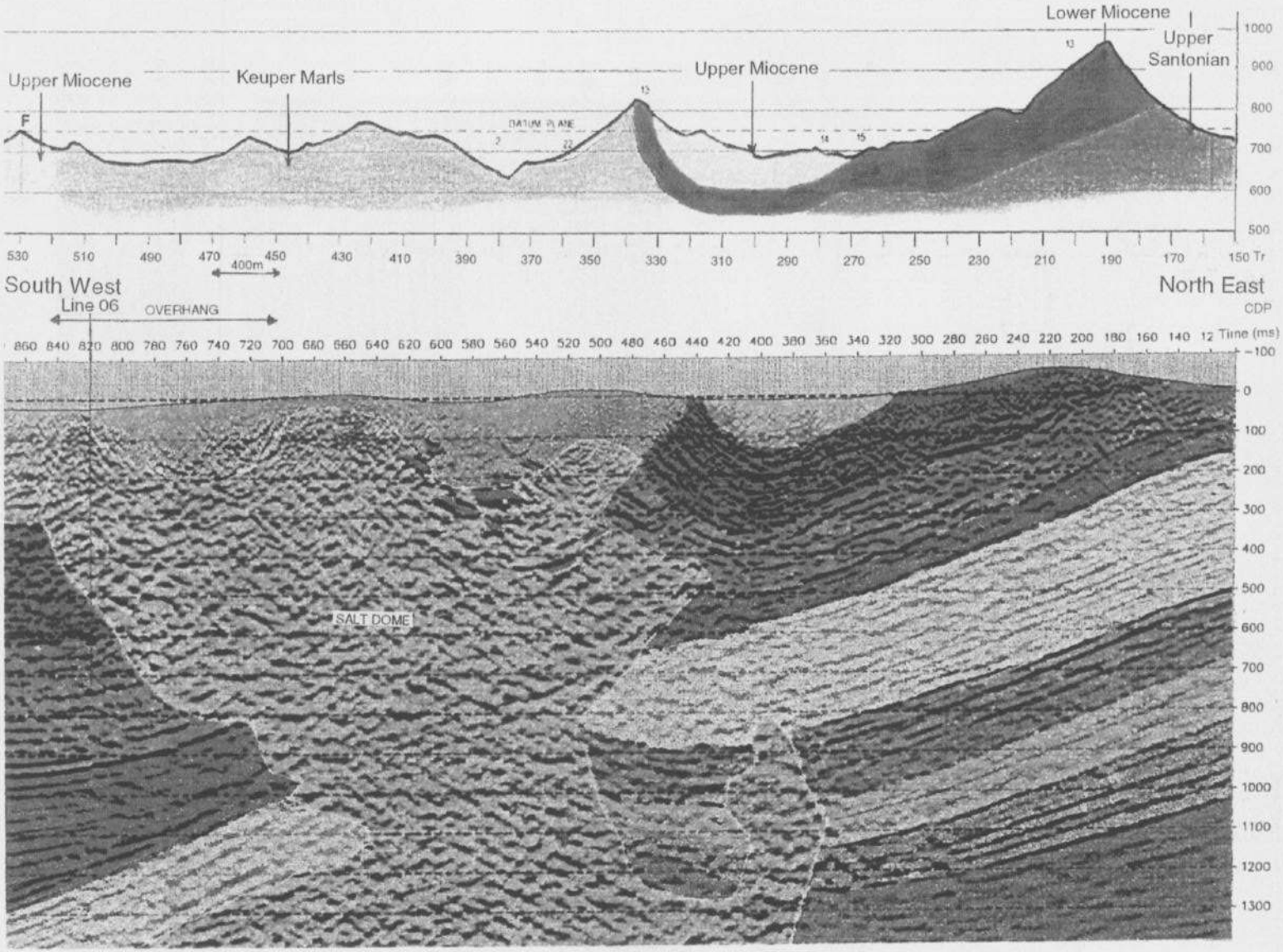

Figure 4. South West - North East seismic line

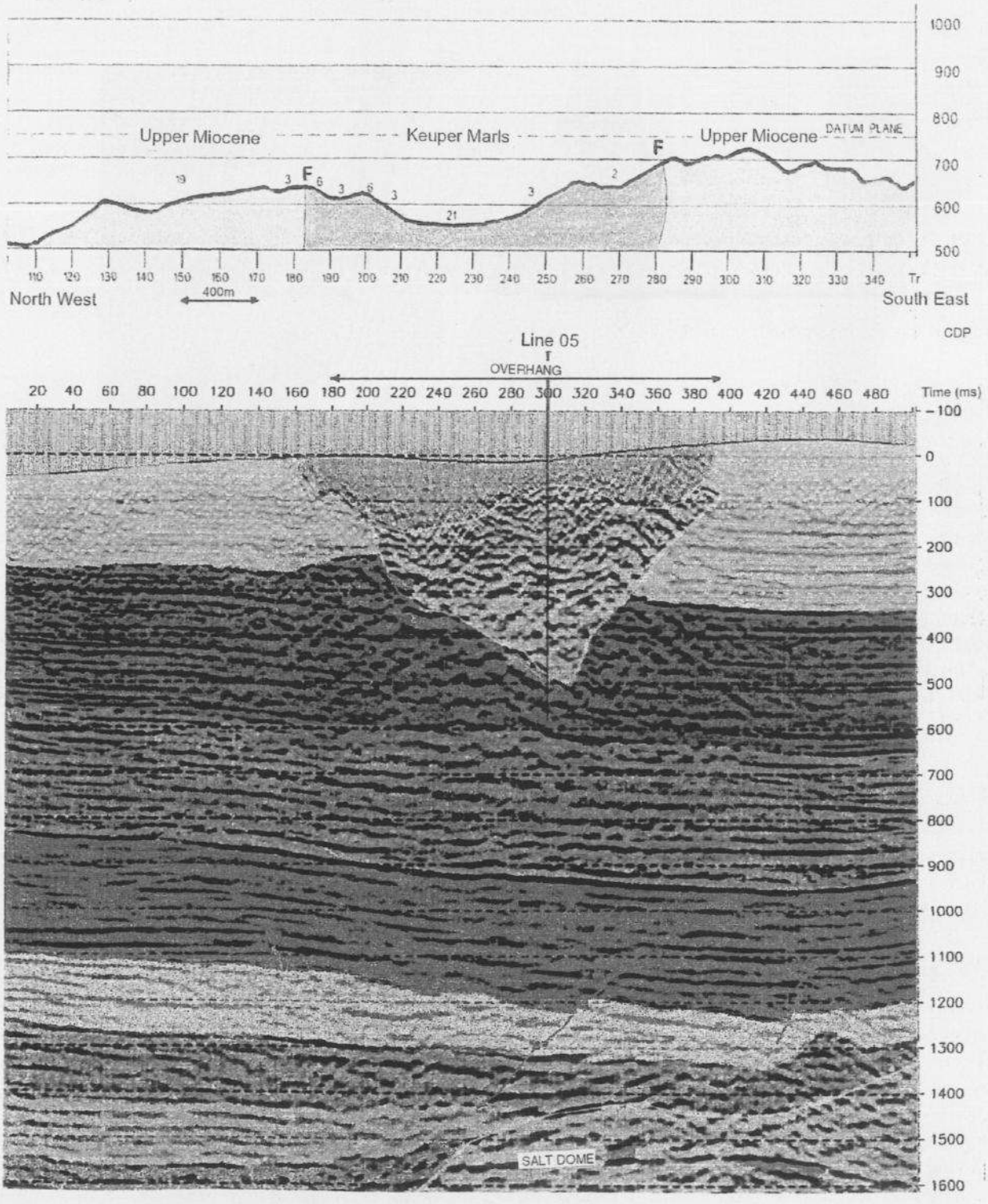

Figure 5. North West - South East seismic line