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History of Geophysical Work for Potash Salt Investigation in the Catalonian Potash Basin - ICL Iberia Súria & Sallent

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SUMMARY

Seismic surveys have been used for potash prospection in the Catalonian Potash Basin since the early 1970's.
More recently, 3D high-resolution seismic surveys have proved to be a powerful tool for potash mine evaluation and planning when professionally designed by geophysicists in collaboration with mining companies. Interpretation by mining geologists for mining engineers is key to achieving an improved geological understanding of the mine. In this case study in-depth seismic interpretation made it possible to obtain a structural geology model as well as produce isobath and isopach maps.
The resources were evaluated after a drilling campaign and a calculation of on-site resources was made using geostatistical methods in compliance with International Standard Codes for Reporting of Exploration Results, Mineral Resources and Ore Reserves (JORC Code).

Introduction

Mining activity in the Cardener and Llobregat valleys of Catalonia, Spain dates back over more than a century, from the discovery of potash salts in Bages in 1912, the first well operations in Suria in 1925 and mining operations in Sallent in 1929. In the second half of the 20th century, several geophysical surveys were conducted to delineate the limits and capacity of the Catalonian Potash Basin.

Long History of Mining in Bages

In 1948, MPS began operations in the Cabanasas mine, NE of Súria, and then became a public company called Súria K in 1982. Iberpotash SA was created in 1998 by acquiring the Potasas Group and later became ICL Súria & Sallent by combining the two active mines (Cabanasas and Vilafruns).

The Cabanasas mine extracts potash and salt at a depth of 680 meters from the hyacinth vein, north of Tordell's fault (*Figure 1*), using one well for access and another for output of salt and potash and ventilation.

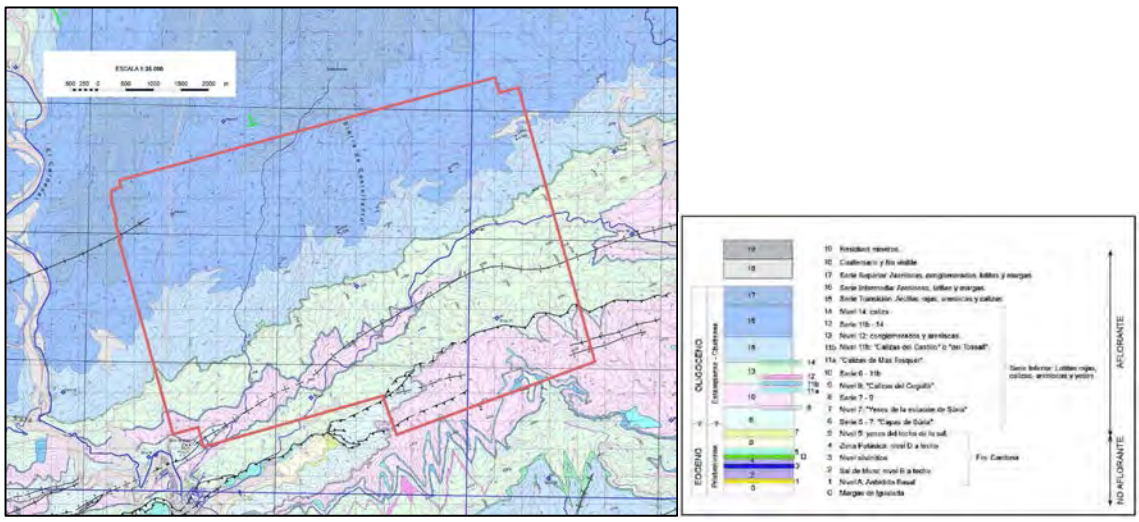


Figure 1 *Geological map of Bages showing Cabanasas 2009 3D survey (from JL Coullault, 1998).*

In 2011 the so-called Phoenix investment plan began which included industrial development throughout Bages, and the investment of more than 240 M€ to increase annual potash production to more than one million tons.

The current construction of a 4.5 km-long ramp at the Cabanasas mine under the supervision of CRS (Consultoría en Recursos del Subsuelo, S.L.) will allow potash extraction and put an end to the current need for more than 500 trucks to drive daily through the municipality of Súria.

Early geophysical work

CGG's long history of involvement with the potash mines in Bages, began when it conducted the first geophysical studies there in the early 1970's, acquiring refraction seismic and the first 2D reflection surveys ever shot in the Catalonian Potash Basin around the Cardona mine, slightly north of the ICL mines. These 24-channel low-fold surveys, using a heavy dynamite source, gave good insight into basin prospectivity.

The first large-scale survey was recorded at the end of the 1980's with a 2D seismic campaign from Llobregat to Segre. Coupled with borehole logging and geophysics, this survey helped to delineate potash levels and estimate the volume in place and was used for Cabanasas mine planning for over next decades. The most important structures in the area are overlapping, retro-overlapping and folds. The project area corresponds to the Pyrenean foothills; the thrusts on this part of the mountain chain come from the north and create overlapping vergence towards the south. The retro-overlap shows northern vergence. The most important structures in the area are the Cabanasas anticline and the Tordell fault. The Tordell fault is a retro-overlap which follows a direction of N64ºE and dips 30º to the south. It is a regional structure with a slip exceeding 1 km. The Cabanasas anticline is situated to the north of the Tordell overlap. It is a regional fold from the Cardona Saline Formation, the core of which is occupied by the Cabanasas Mine. The fold shows a direction of N60ºE and a subvertical axial plane with 5º to 30º dips in the northern limb and up to 60º in the southern limb.

Why seismic?

The seismic method is used to discriminate potash salts from other salt or clay intercalations and predict structural events such as:

- Normal or reverse faults;
- Sudden breaks in the potash bed due to sedimentary or structural phenomena;
- Optimise mine planning and estimate volume in place that can be exploited mechanically.

How does it work?

The seismic method is sensitive to rock velocity and density. All evaporite rocks have high velocities and it is therefore difficult to discriminate based on velocity alone.
Fortunately, the density of the different types of salt is quite variable from 3.85 for anhydrite to 1.6 for carnalite or 2.16 for halite. A cross plot of logged sonic and density values from one borehole show how salts can be identified through their density (*Figure 2*).

In the Catalonian Potash Basin there is a constant layer of anhydrite at the base of the evaporitic sequence (*Figure 3.*). As anhydrite has the highest velocity and density, it serves as a good reference.

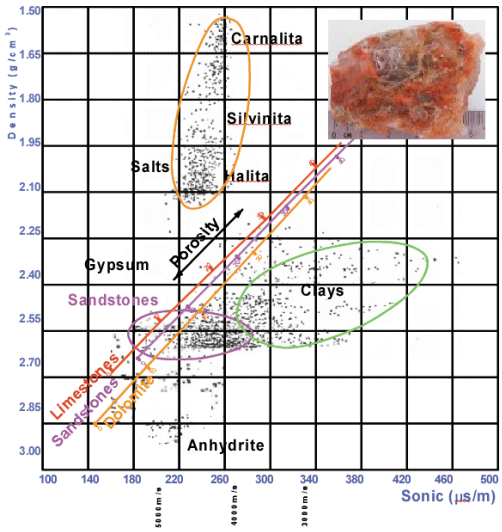


Figure 2 *Cross plot of sonic and density values from one borehole in Cabanasas mine.*

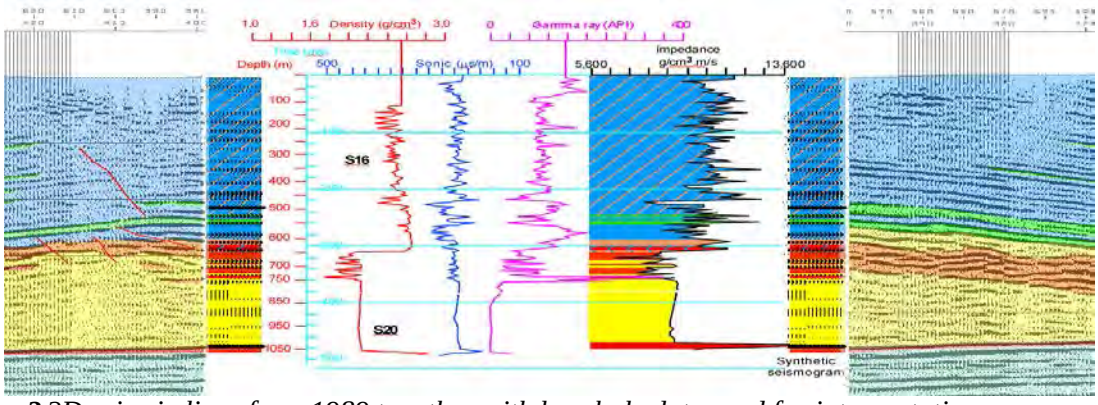
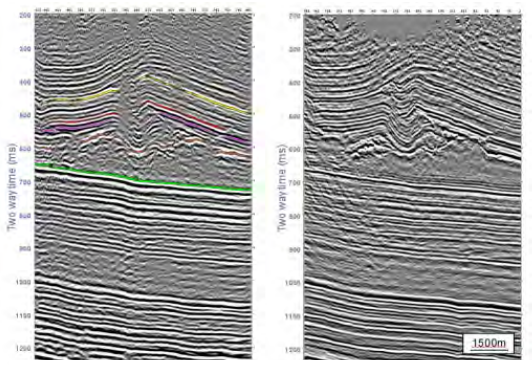


Figure 3 *2D seismic lines from 1989 together with borehole data used for interpretation.*

The 3D turning point at the Cabanasas mine

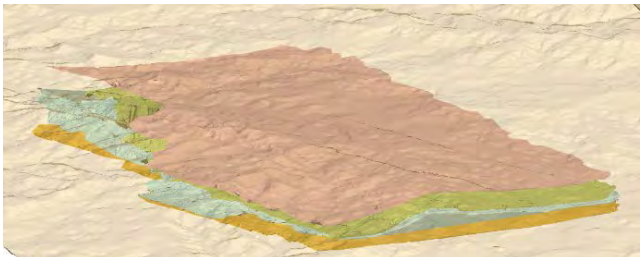


After the successful application of 2D seismic, the first move towards 3D was made in 2007 when CGG performed a feasibility study at the request of CRS over a 50km² area across the Cabanasas mine leading to the acquisition of the first 3D ever shot over a mine in Spain. The 3D survey was successfully recorded and processed in 2009 by CGG (comparison with 2D is shown on *Figure 4)*, then interpreted by CRS to ensure the existence of mineable reserves from the current pit location.

Figure 4 *Comparison of 1989 2D and 2009 3D seismic lines over the Cabanasas mine.*

The survey deployed a cable-based Sercel 408 recorder with only a *pop-shot* (small shallow charges) dynamite source. The grid was rather dense as the target depth was less than 1000m. Critical issues were public relations and careful attention to environmental constraints. Onsite data processing shortened the decision process and inferral of borehole positions.

The following methodology was used to obtain the depth from the 3D seismic volume: obtain the initial velocity model in time, obtain depth values from Floating Datum Plane, obtain gross seismic volume in depth, the lag of time horizons and generation of delagging maps and obtain final volumes in depth. The in-depth seismic interpretation made it possible to obtain a structural geology model of the geological units present within the volume as well as produce isobath and isopach maps of the units interpreted (*Figure 5*).



CRS evaluated the resources in the area after a borehole campaign and calculated on-site resources using geostatistical methods in compliance with International Standard Codes for Reporting of Explorations Results, Mineral Resources and Ore Reserves (JORC Code, NI 43-101).

Figure 5 *3D geological model (image made with Vulcan 3D).*

3D as an exploration tool west of Cardener

As the two mines of Suria and Villafruns did not have sufficient capacity to meet the increase in production, expected by the Phoenix plan, it was necessary to look for the mining potential of another site accessible from the present infrastructure but west of Cardener.

As a result of their geological expertise of the basin, CRS delineated the new 3D survey location, named Pozo IV.

This new 3D survey was carried out over a 76 km² area west of the Cabanasas mine. Data collection was this time carried out by CGG with a Sercel UNITE wireless recorder and the latest Sercel Nomad 15 vibrator (*Figure 6*) was used for the first time to reduce the environmental footprint.

Figure 6 *Sercel N15 vibrator and UNITE wireless system.*

Using the promising results obtained from the combination of vibroseis and pop shot on the Pozo IV survey (*Figure 7*), a new 3D program is now planned for this year to develop the Cabanasas mine east of the previous 2009 3D survey and secure mining resources for the next decades.

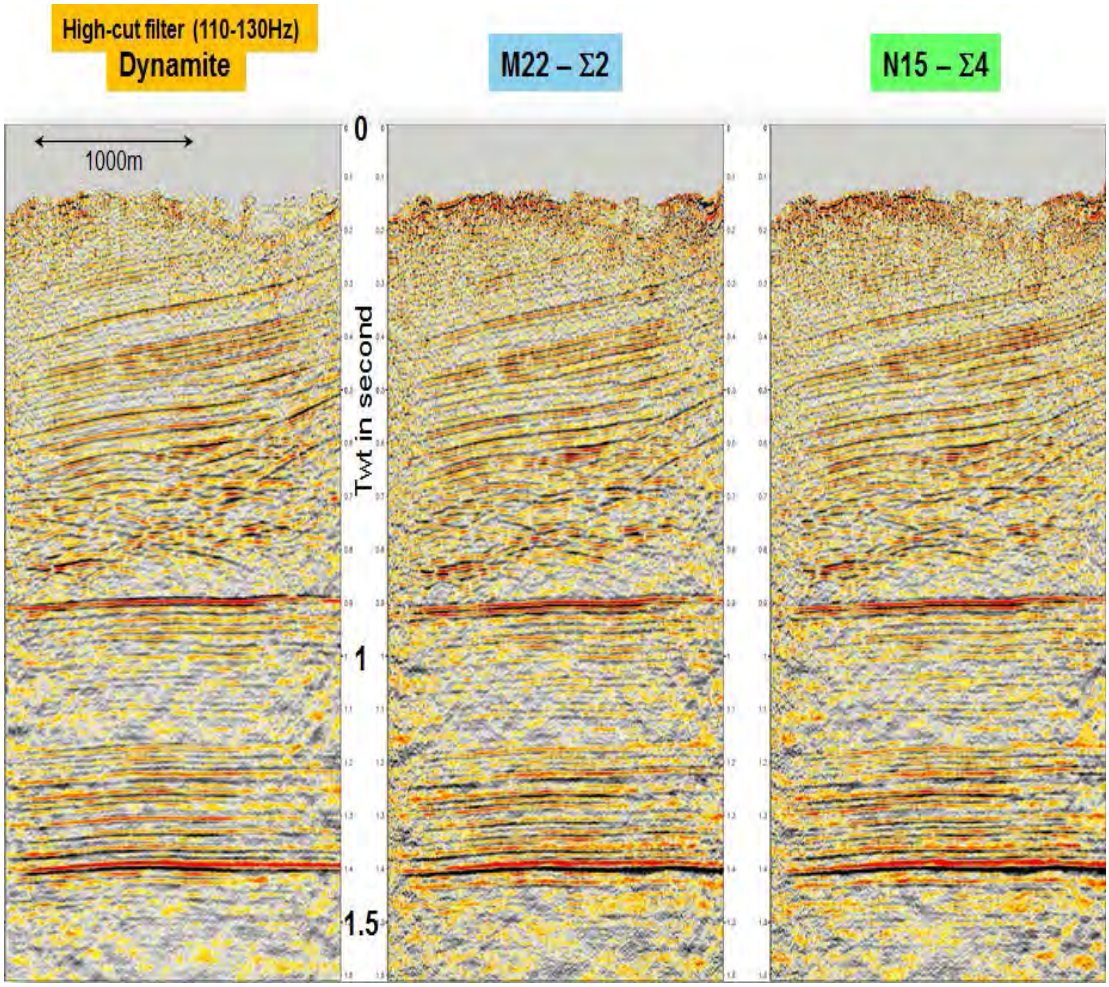


Figure 7 *Comparison of seismic sections obtained using pop shot (left) and two different vibroseis sources M22 (center) and N15 (right) showing that vibroseis can be used as seismic source.*

Conclusions.

Seismic, both 2D and 3D, has proved over the recent history of potash mines in Catalonia to be a powerful tool for mine evaluation and planning when professionally designed by geophysicists in collaboration with mining geologists. Interpretation by mining geologists for mining engineers has proved to be key to achieving an improved geological understanding.

References

Coullault, JL. [1998] Plan General de exploración de la Cuenca Potásica Catalana, *AURENSA report for Súria-K.*

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