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GEOPHYSICAL PROSPECTING

EXPERIENCE WITH THE REFLECTION SEISMOGRAPH IN A MINE WITHIN A SALT-PLUG*

Günther Wachsmuth and Edgar Schmidt

SUMMARY

By further technical development and by introduction of new construction procedures seismic surveys carried out underground within mines obtained a new rise. Interesting seismic records in three components are shown and discussed. A vertical section containing results of seismic research investigations and of drilling is shown.

The experience with the reflection seismograph within the potash-mine of Hattorf of Vereinigte Kaliwerke Salzdetfurth A. G., which has been obtained in 1959 on occasion of a research program of Forschungsgemeinschaft Seismik e. V., made it desireable to improve the outfit and the equipment before starting with new research work.

The outfit was provided with a low-pass-filter, which makes it possible to separate the high-frequent noise cleanly from the lower-frequent reflections and to suppress it.

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A programmed-gain-control acting in various short time-intervals, which has been developed especially for the outfit used in mines, has proved to be very useful during the investigations in the salt-mine of Mariaglück of Vereinigte Kaliwerke Salzdetfurth A.G., because it is very adaptive concerning the energy conditions under-ground.

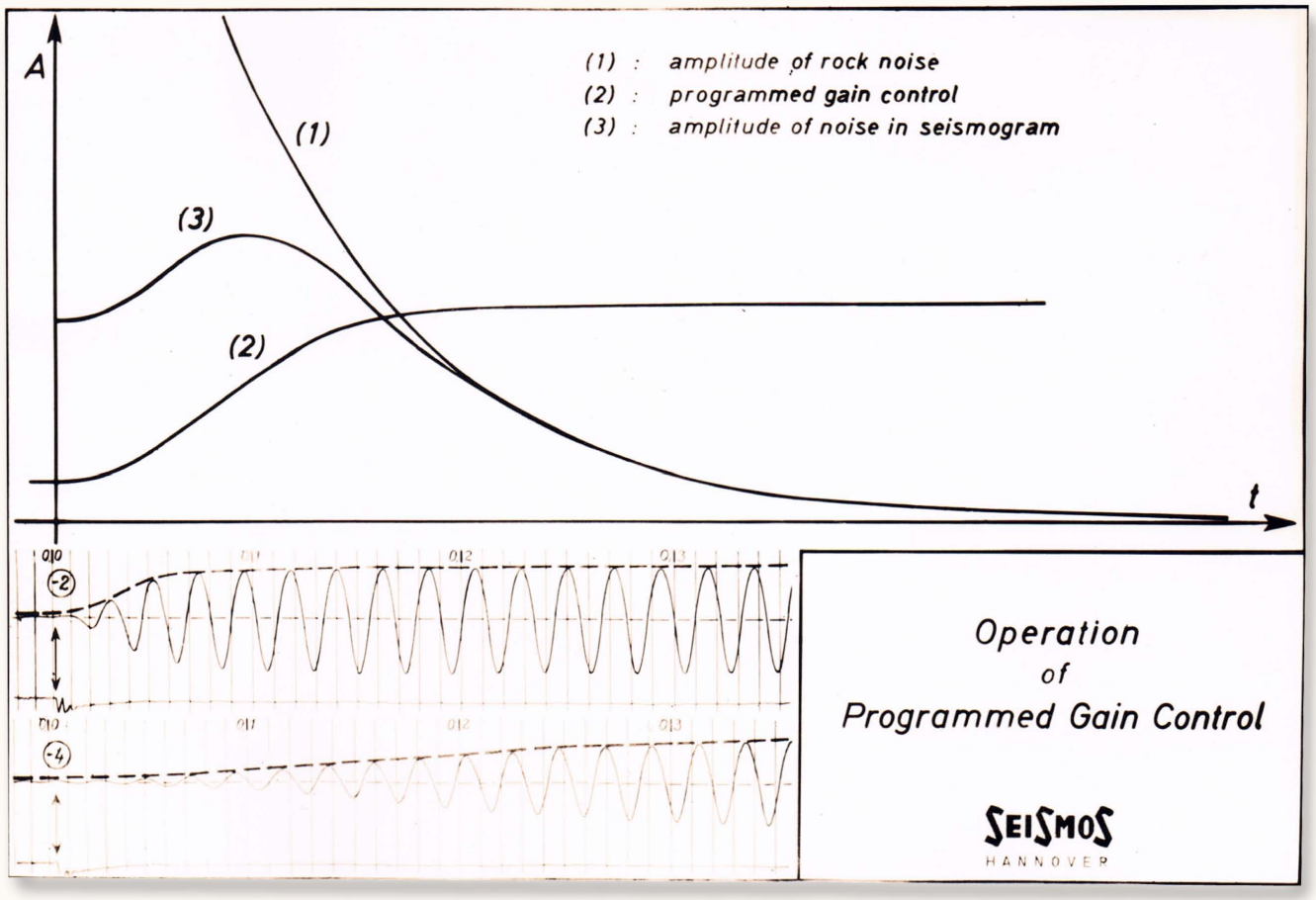
Intentionally it has been desisted from using the automatic-gain-control in order to maintain the possibility of controlling the true amplitudes.

In the first picture two programmed-gain-control curves can be seen, which clearly show the action of the programmed-gain-control. In the upper part of the picture it is schematically delineated, how the high amplitudes, which set in just after the shot, are pressed down to the desired altitude in the seismogram by the action of the programmed-gain-control. In general this device is released by the shot-time-break, but it can be released later - if desired - if this becomes necessary at great distances of the shot-point.

For attaching the geophones to the wall, the equipment was enriched by cubes of aluminium, by which it is easily made possible to measure all the three components of the movement of the rock. Picture 2 gives an idea how this is done. The cubes, which can carry geophones in the X-, Y-, and Z-positions as desired, are screwed to a bolt, which is put into a small bore-hole and fastened to the rock by gypsum.

Due to the better adaption of the outfit to the requirements of seismic, carried out within mines, it became possible to choose a smaller distance from shot-point to geophone-spread than in former investigations. The consequence was that in the seismogram only LL- and TT-reflections appeared, whereas LT-waves (which are longitudinal on the way from the shot-point to the reflecting plane and transversal on the way back to the spread) and TL-waves could be observed only exceptionally. The guided TLT-waves were not observed. By this, interpretation became substantially easier.

By the observation in three components it became possible to find out unequivocally the type and direction-of-oscillation of a wave, provided that the approximate position of the reflecting plane is known.



Pic. 1

Operation of Programmed Gain Control

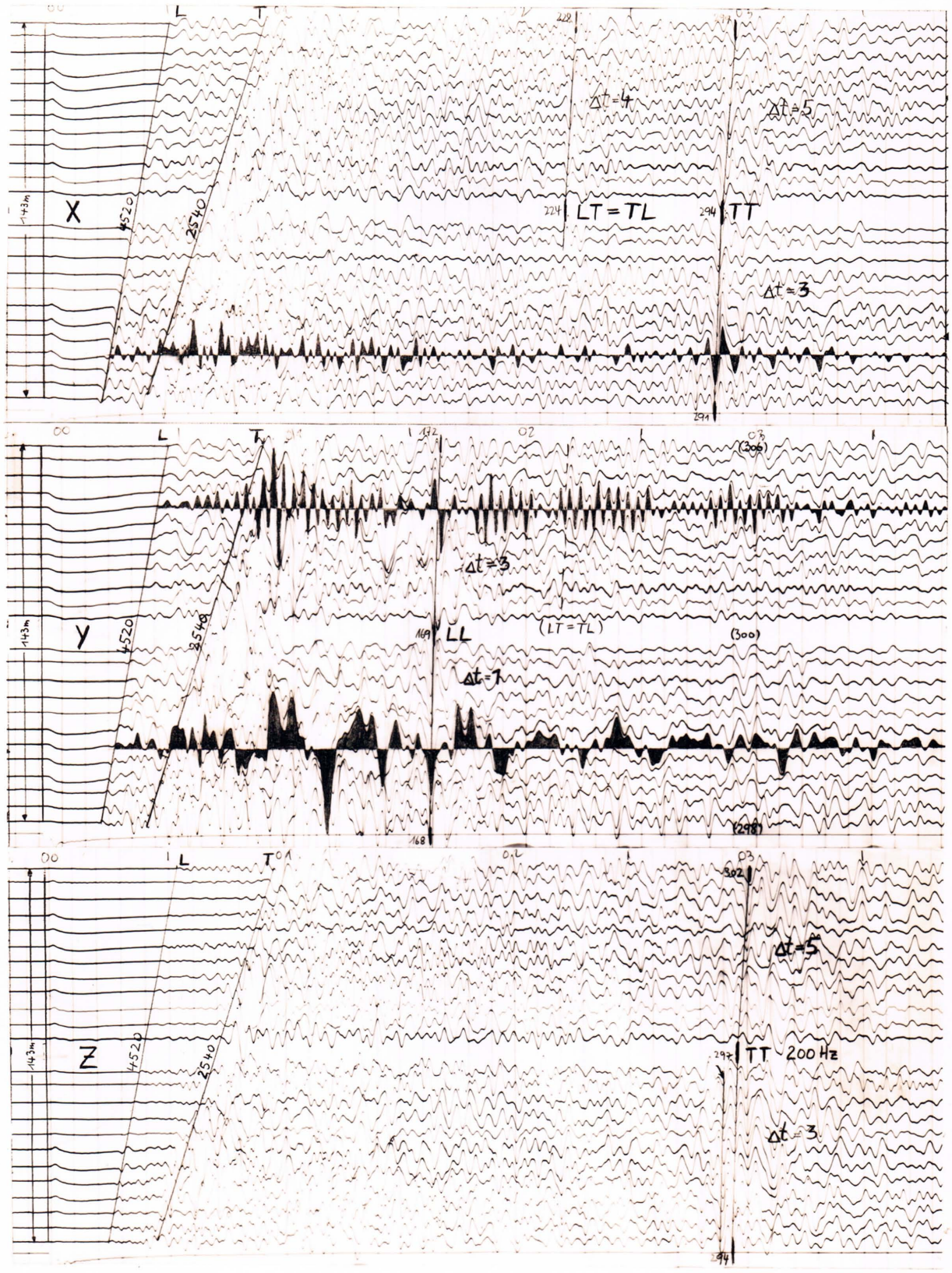
Pic. 2

Picture 3 shows an example. The shot-point was positioned at a distance of 100 m from geophone 24 in the prolongation of the geophone-spread. The reflecting plane was vertical and parallel to the spread at a distance of 350 m.

At thes constellation the longitudinal first-arrivals should be predominant especially in X, the transversal first-arrivals only in the Y- and Z- components. This - in the present case - is blurred by the action of the programmed-gain-control, but it can still be realized.

The reflected LL-wave should appear in Y, but not in X and Z. This can be clearly recognized. The reflected TT-wave - to the contrary - should appear in X and Z, but not in Y. This can also be clearly seen. The LT-wave has a measuralbe amplitude only at a large distance from the shot-point, that means at large reflection-angles. As it appears well in X and somewhat weaker in Y, but not in Z, it is proved that the LT-wave is polarized in the plane of incidence, as it should be.

Special attention has been drawn to the behaviour of three traces by blackening the amplitudes. In the upper trace the geophone swings normally. In the second trace a beat can be clearly perceived. The beat could come about because grouping of geophones was used. Two of the systems of geophone plus geophone-carrier of the group were incited by the noise to swing with their natural frequency as the damping of the systems was too weak. Appearances of this kind can be removed either by attaching the screws of the systems more firmly and thus raising their natural frequency or by increasing the damping through a better contact to the wall. In the lowest trace an abnormal oscillation can be seen, which is due to a very common cause. The additional gradient of rock pressure, which arises on the sides of a newly driven road, is the cause for the



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Seismic Record in Three Components

Pic. 3

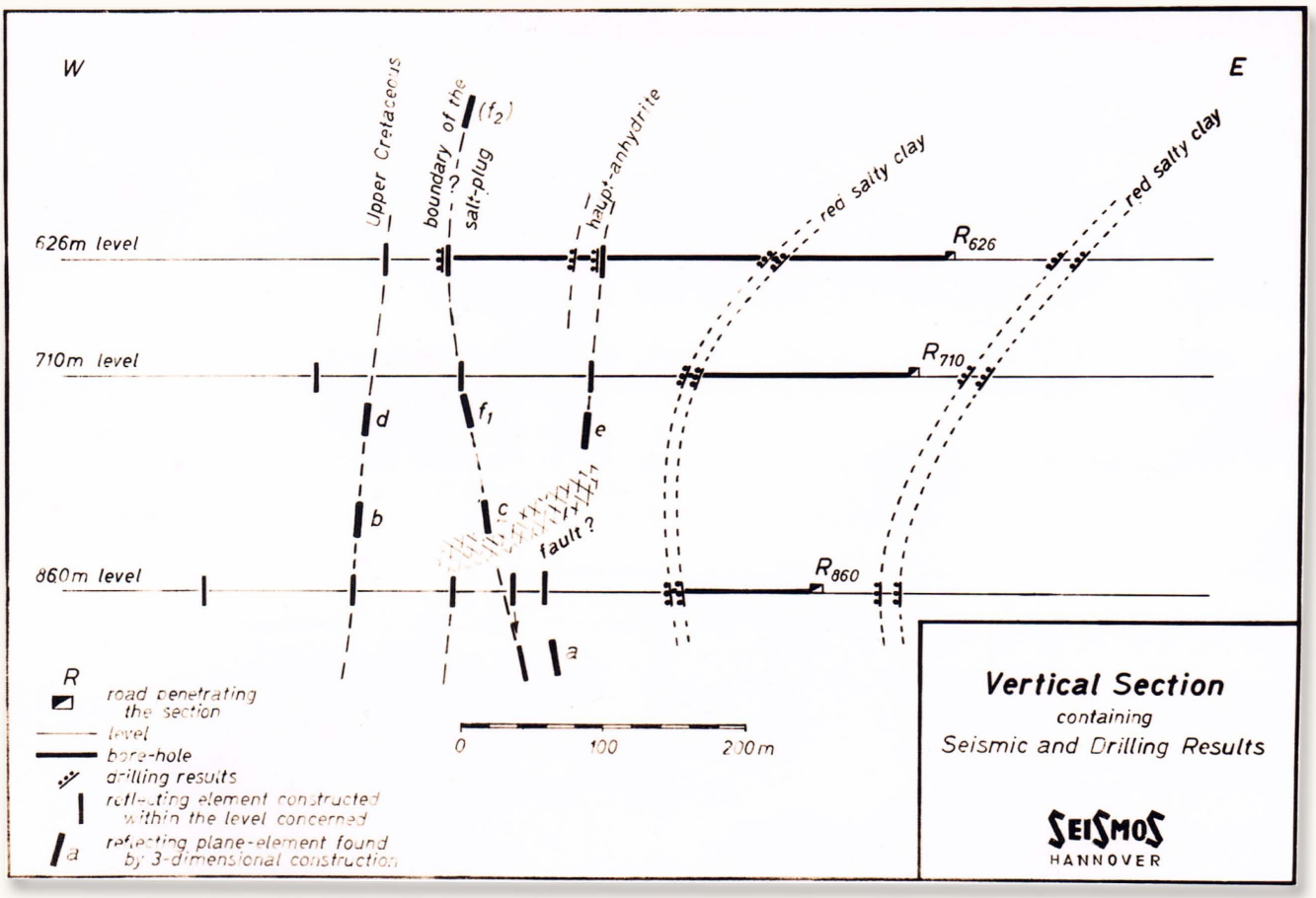
break-limit of the rock material to be surpassed after a certain time. Therefore plates - the extension of which can reach several meters in any direction - are loosening from the side-walls. By the energy of the blast these plates are incited to swing with low frequency, and are thus dirturbing the seismogram. It has been managed, however, to eliminate the oscillations by using an appropriate high-pass-filter.

Concerning the technique of evaluation considerable progress has been achieved lately. A paper about three-dimensional construction of reflection-points by geometrical methods is going to be published by Edgar Schmidt. In this place the reader should be informed about the Hilfskugelverfahren (which can be translated by "auxiliary-spheres-procedure"), which is used, if the problem is to find out the intersection-curve of two penetrating rotation-ellipsoids. This problem occurs, if the reflection-points are constructed according to the ellipse-method and if account shall be rendered of all possible positions of the reflection in the space. The result is a zone, which significates these positions.

The Hilfskugelverfahren can be applied, if the axes of two rotation bodies are intersecting. The construction has to be carried out in the plane, which is formed by the axes. Around the intersection-point of the axes auxiliary-spheres have to be placed, which cut circles out of the two rotation bodies. The intersection-points of two corresponding circles are points of the intersection-curve of the rotation-bodies.

Picture 4 shows some of the results obtained during the research-investigations in the mine of Mariaglück in winter 1961 to 1962. The picture is representing a vertical section containing results of seismic investigations. Moreover, interfaces found by horizontal drilling are plotted down.

The section is penetrated by roads R in three different levels, where the investigations took place. By drilling have been found: in the 626 m - level the boundary of the salt-plug, 20 m of hauptanhydrite and red salty clay; in the 710 m and the 860 m - levels drilling has been abandoned, when red salty clay had been reached. The seismic



Pic. 4

VERTICAL SECTION containing Seismic and Drilling Results

measurements have been performed generally that way that shooting and recording took place at the same level. At the first evaluation shift was made by assuming vertical dip of the reflecting planes and constructing according to the ellipse-method within the level concerned. Although some inaccuracy arose by this procedure, it has been already succeede in eliminating by geological arguments the second version always occuring, and in finding reflecting horizons of larger extension.

Two angular geophone-spreads allowed the accurate three-dimensional construction of the reflecting planes. One of these angular spreads was positioned at the deepest level that way, that one branch of it extended in the road R_{860} while the other branch was set up upwards in a blind-shaft. It has been shot from the deepest and the middle levels. The reflections a to e resulted from this spread. On the upper level a second angular geophone-spread has been built up, the branches of which laid within the level and intersected at an angle of about 80°. The corresponding shot-point was positioned in the same level. An ambiguous reflection resulted which es marked by f_1 and f_2. Unfortunately the ambiguity could not be abolished because of lack of further investigations.

The interpretation of a part of the reflections was difficult, because the number of observations has been too small. It was relatively easy, however, to determine a reflecting layer of the Upper Cretaceous outside the salt-plug, which is steeply turned up. The reflection e has been attached to the haupt-anhydrite, which has an extremely high reflection-coefficient. The same refers to the reflection a.

The knowledge of the salt-plug-boundary is of vital importance to the miner in order to avoid inrushes of water or oil. This boundary could be persued from the upper level via f to c and further, but the interpretation below c is not quite unequivocal.

In the present case a special difficulty in the interpretation of the seismograms was, that the reflections did not well maintain their character from place to place, probably

because of focussing or dispersion at the reflecting interface. Therefore correlation according to the character of a reflection was hard.

According to our experience of to day seismic investigations within salt-mines make it possible to persue continuously the border of a salt-plug and eventually of other interfaces too (for instance of the haupt-anhydrite), at least, if the possibility of tiing reflections to the results of drilling is existing now and then.

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