PRAKLA-SEISMOS GMBH

Firedamp Proof Seismic Digital System

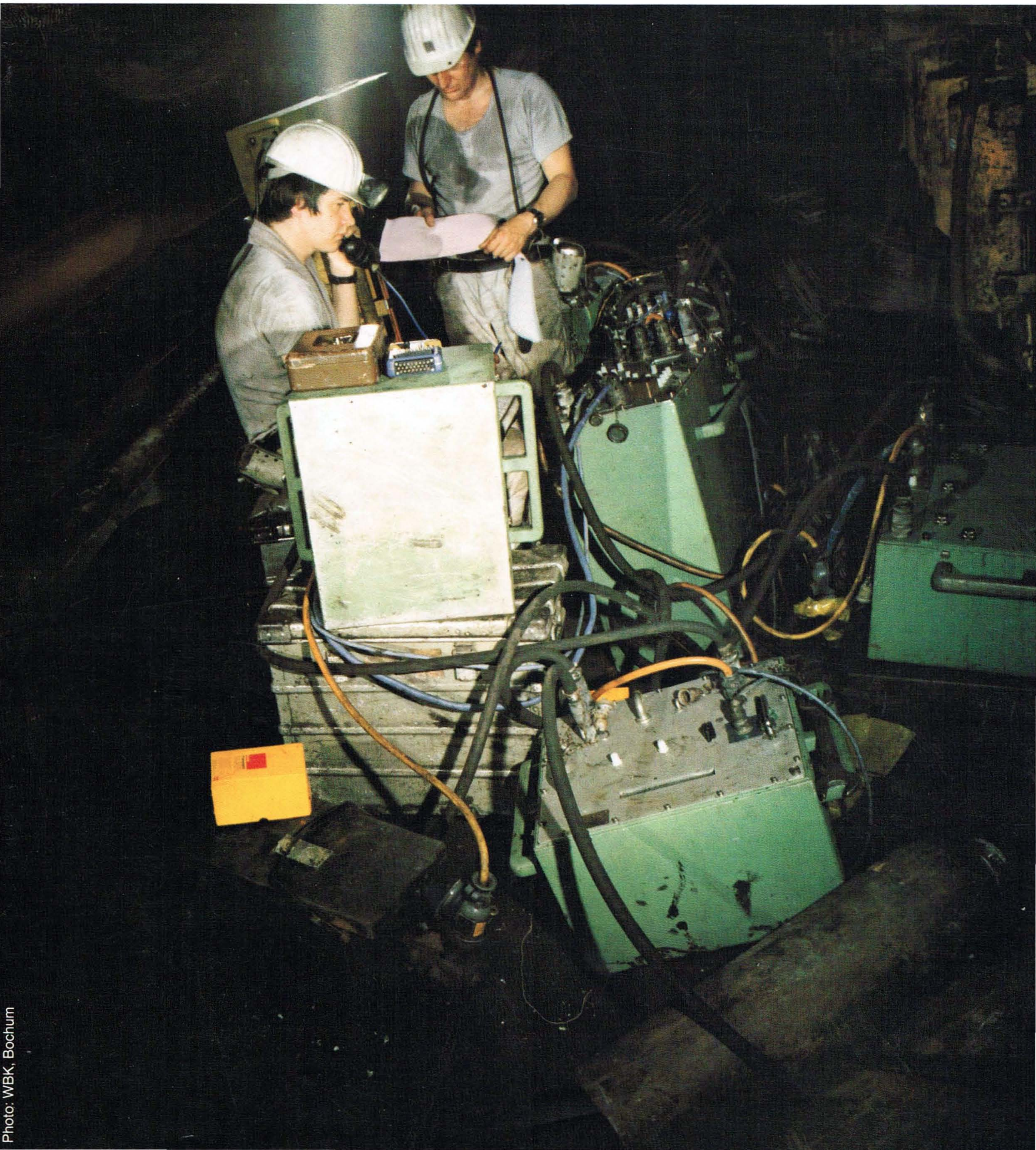


Photo: WBK, Bochum

Unexpected tectonic faults, even minor ones with throws of only a few feet, which cannot be detected by surface seismic methods, always mean a loss of productivity as they present severe working problems for fully mechanized longwall coal faces; they may even stop the face advance. Therefore, it is of increasing importance to explore the zones ahead of the faces and to accurately predict the continuity of the coal seam as well as the positions of unknown faults within the seam including their throws in relation to the seam thickness.

In-seam waves are channel waves which are generated within the coal seam, guided along the seam and received within the same seam. They propagate solely within the coal seam, which is a channel of low acoustic impedance, normally much lower than that of the surrounding rocks. In general coal has acoustic impedances which are only a quarter to a third of those of the surrounding rocks. As the P-wave velocity difference between rock and coal increases so the energy of in-seam waves is more strongly tied to the seam. Owing to this fact, Love-type in-seam waves have proved to be particularly favourable for in-situ surveys. The particle motion of these waves is aligned parallel to the centre plane of the seam and perpendicular to the direction of wave propagation; symmetrical Love waves have maxmium amplitude at the centre plane of the seam. Therefore, shots as well as geophones are placed at the centre of the seam. To separate the Love-type waves from other waves two-component geophones are used.

The methods for in-seam seismic surveys are:

Reflection surveys, in order to detect and locate tectonic faults within the coal seam.

When the coal seam is totally or partly cut off by a tectonic fault, different acoustic impedances arise on either side of the fault, thus it acts as a seismic reflector. In order to optimize the reflection results, multiple coverage of the reflection points has become standard practice. Stacking of reflected wave trains, as well as of their envelopes, and estimations of the maximum amplitudes of stacked envelopes yield very precise predictions of the positions of faults within the coal seam.

Transmission surveys, in order to estimate the magnitude of the fault throw in comparison to the thickness of the seam.

As the wave energy is tied to the seam, no in-seam wave can be observed behind a fault with a throw greater than the seam thickness. On the other hand, the observation of good in-seam waves means that if a fault does exist it has a throw of less than the seam thickness. Optimization of transmission results is achieved by computationally rotating the geophone axes: one component points towards the shot and receives mainly compressional waves; the other component, perpendicular to the first one, records mainly shear waves.

Whereever possible both methods should be combined.

Fig. 1a:
Location map of seam N (before start of face advance) showing two fault predictions resulting from a reflection survey using spread A (seismogram sections see fig. 4). A transmission survey using shotpoint I and part of spread A showed that the fault throw within the transmitted area was equal to the seam thickness. In addition, from exposures of the fault in the roadways a decrease of the throw from north to south is indicated.

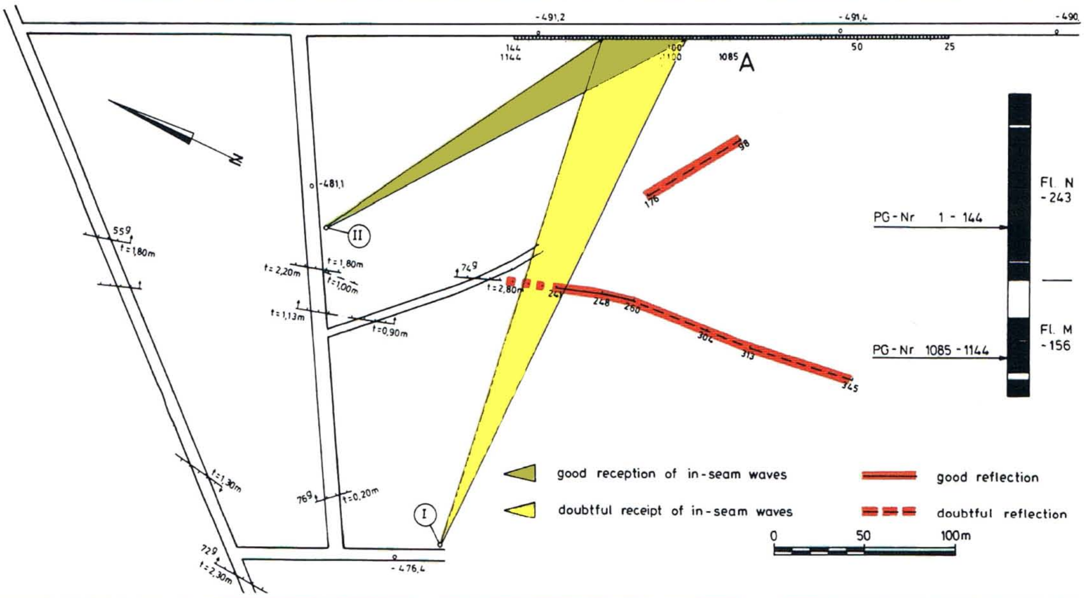
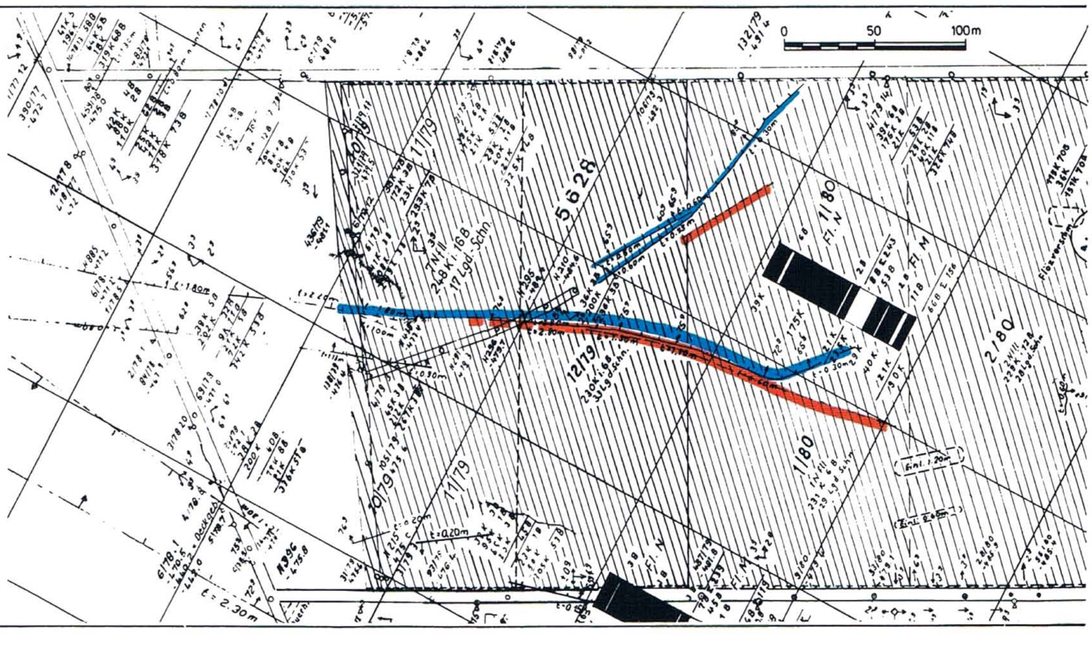


Fig. 1 b:
Location map of seam N (after exploitation) showing the predicted (orange) and the actual positions (blue) of two faults: the predictions were quite accurate; the prediction error was only between 1 and 4 m. Where the throw decreased to about 30 cm, the prediction error was somewhat greater; this was due to a poorer reflection quality.



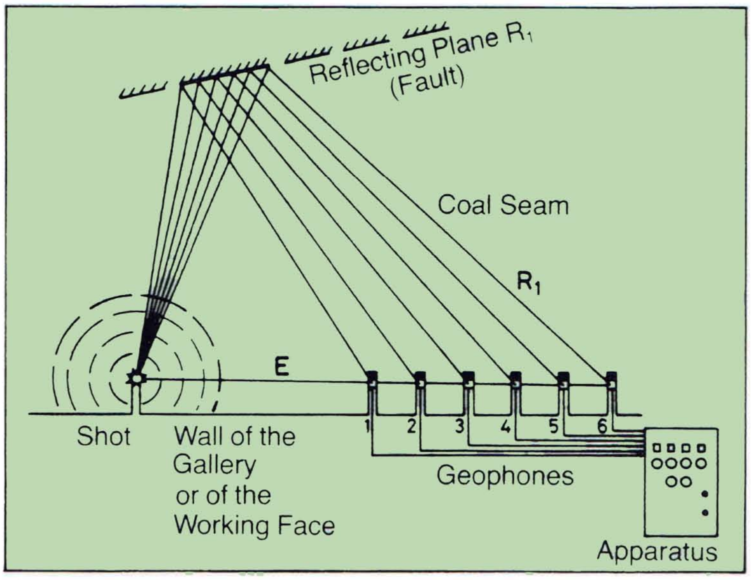


Fig. 2: Principle of the Reflection Method

When using the **reflection method,** one access roadway or faceline must be available in order to establish both the shots and the geophone spreads.

The reflection seismogram contains:

- the P-wave (see fig. 3, P_d), which has travelled through the surrounding rock and occurs as first arrivals, followed by
- the in-seam wave (see fig. 3, C_d), which has travelled along the wall of the roadway or faceline, and
- the reflected in-seam waves (see fig. 3, C_r), if reflections occur.

The relative strength of these arrivals on the two components depends on the angle between the components and the direction of arrival.

As the in-seam wave energy is tied to the seam, no further information can be obtained from behind a fault with a throw larger than the seam thickness. Several successive faults, however,can be detected if their throws are less than the seam thickness.

To receive reasonable reflections, the angle between the centre plane of the seam and the fault plane should be larger than about 30°; on the other hand the dip of the seam does not influence the reflection results.

Reflections from faults at distances corresponding to 150 times the seam thickness have been observed in the past and proved to be correct.

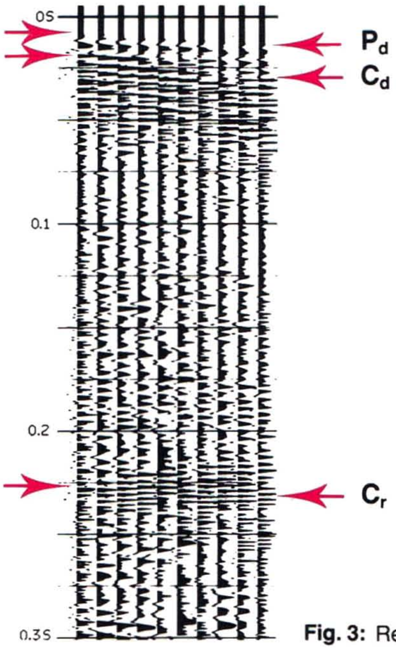


Fig. 3: Reflection seismogram

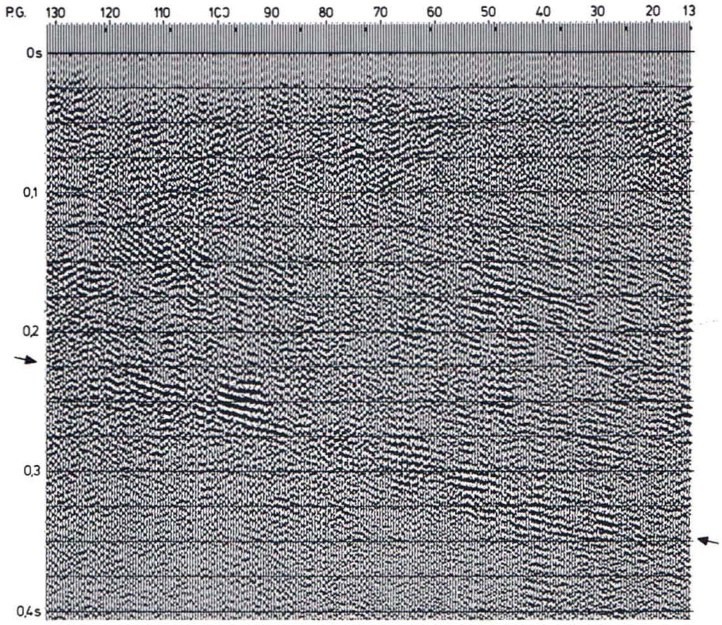


Fig. 4a: 6-fold stack

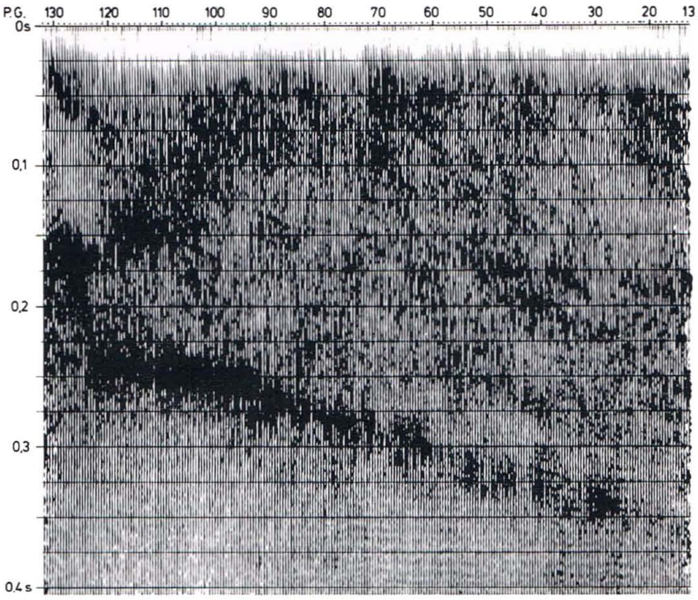


Fig. 4b: 6-fold stack of envelopes

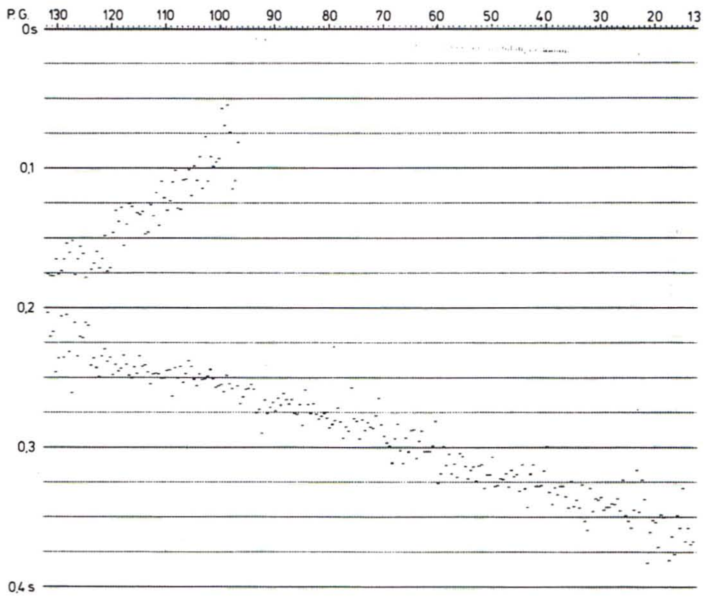


Fig. 4c: Maxium values of amplitudes of stacked envelopes

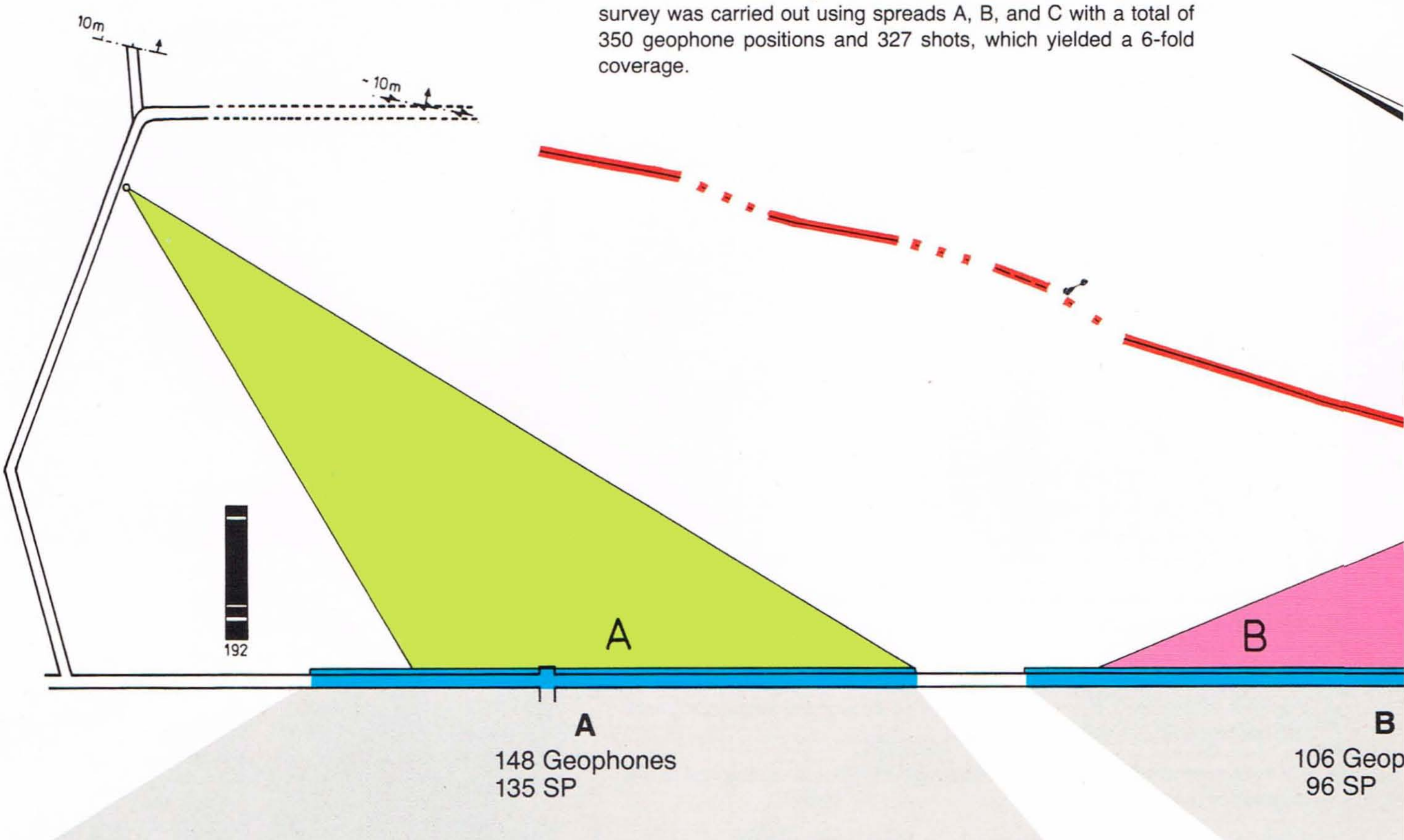


Fig. 5: Location map of Hermann-Gustav seam showing the prediction of a fault with throws larger than the seam thickness. The reflection survey was carried out using spreads A, B, and C with a total of 350 geophone positions and 327 shots, which yielded a 6-fold coverage.

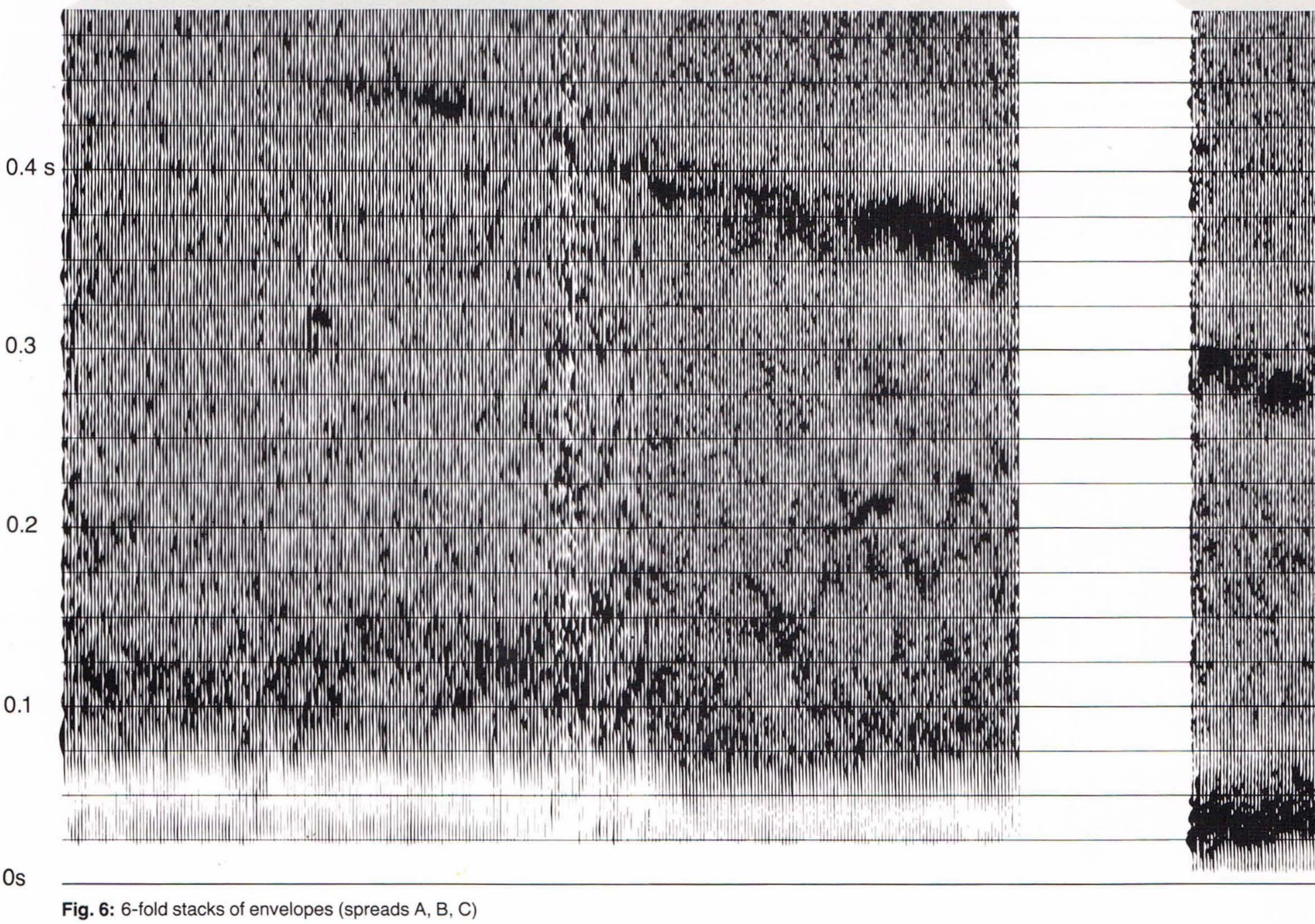
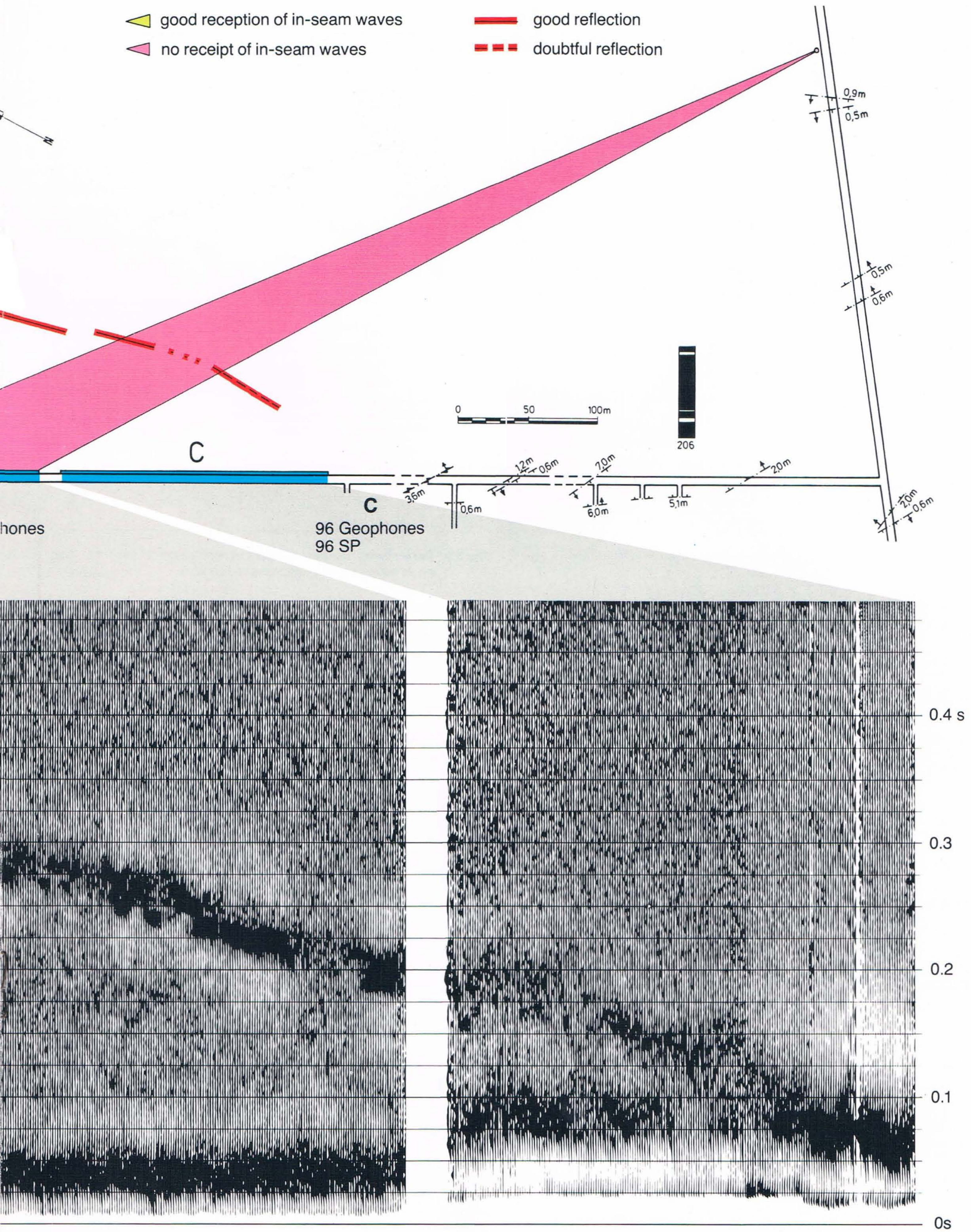


Fig. 6: 6-fold stacks of envelopes (spreads A, B, C)


good reception of in-seam waves
no receipt of in-seam waves
good reflection
doubtful reflection
0,9m
0,5m
0,5m
0,6m
0 50 100m
206
C
1,2m
0,6m
7,0m
2,0m
3,6m
0,6m
6,0m
5,1m
2,0m
0,6m
C
hones
96 Geophones
96 SP
0.4 s
0.3
0.2
0.1
0s

When using the **transmission method,** one access roadway or faceline must be available for establishing the geophones, whilst another roadway giving access to the same seam is required for shot positioning; the in-seam waves can then be transmitted across the zone in question.

The transmission seismogram contains:

- the P-wave (see fig. 8, P), which has travelled through the surrounding rock and occurs as first arrivals, followed by
- the S-wave (see fig. 8, S), which has travelled through the surrounding rock, and
- the in-seam wave train (channel waves, see fig. 8, C).

The relative strength of these arrivals on the two components depends, again, on the angle between the components and the direction of arrival.

When in-seam waves of good quality are observed, it can be concluded that if a fault does exist, it must have a throw of less than the seam thickness. In-seam waves of average to poor quality indicate the presence of a fault with a throw approximately equal to the seam thickness, whereas a complete lack of in-seam wave arrivals indicates a fault or other disturbance with a throw larger than the seam thickness.

Numerous transmission surveys have been successfully carried out at distances of up to 1000 times the seam thickness.

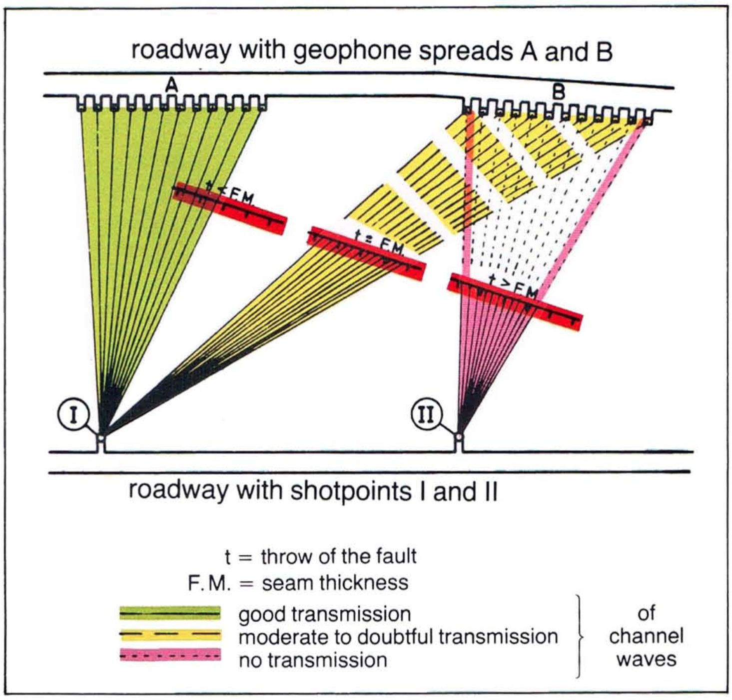


Fig. 7: Principle of the Transmission Method

Fig. 8a: Transmission records showing clear channel waves (green zone)

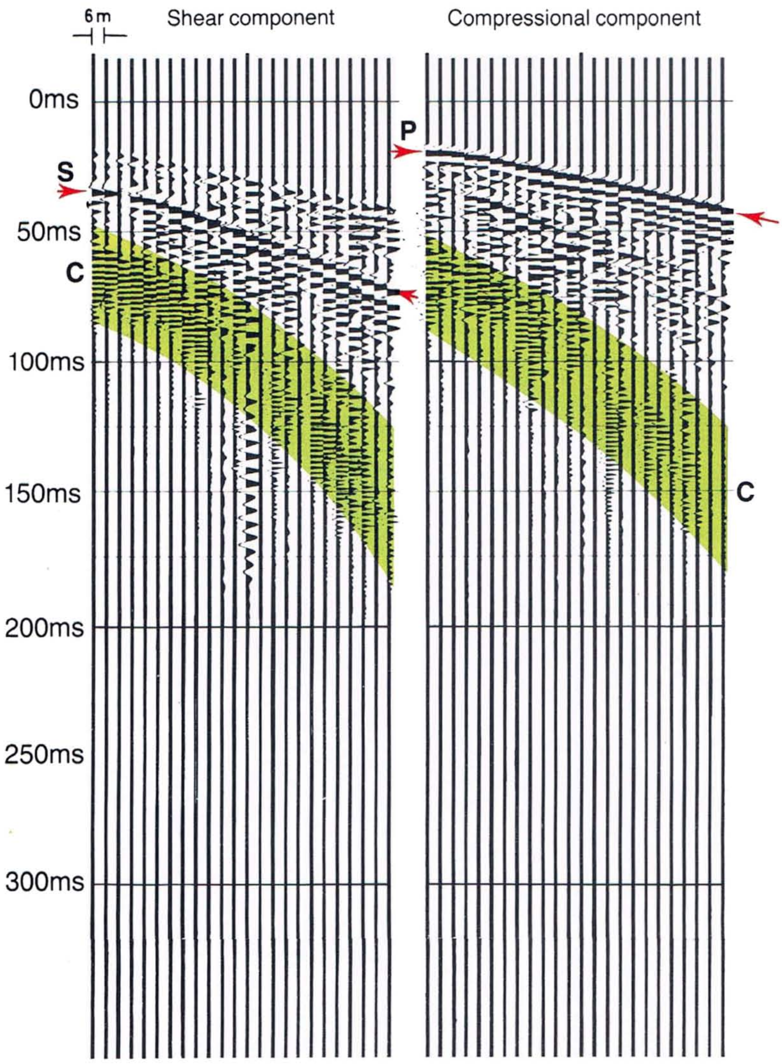
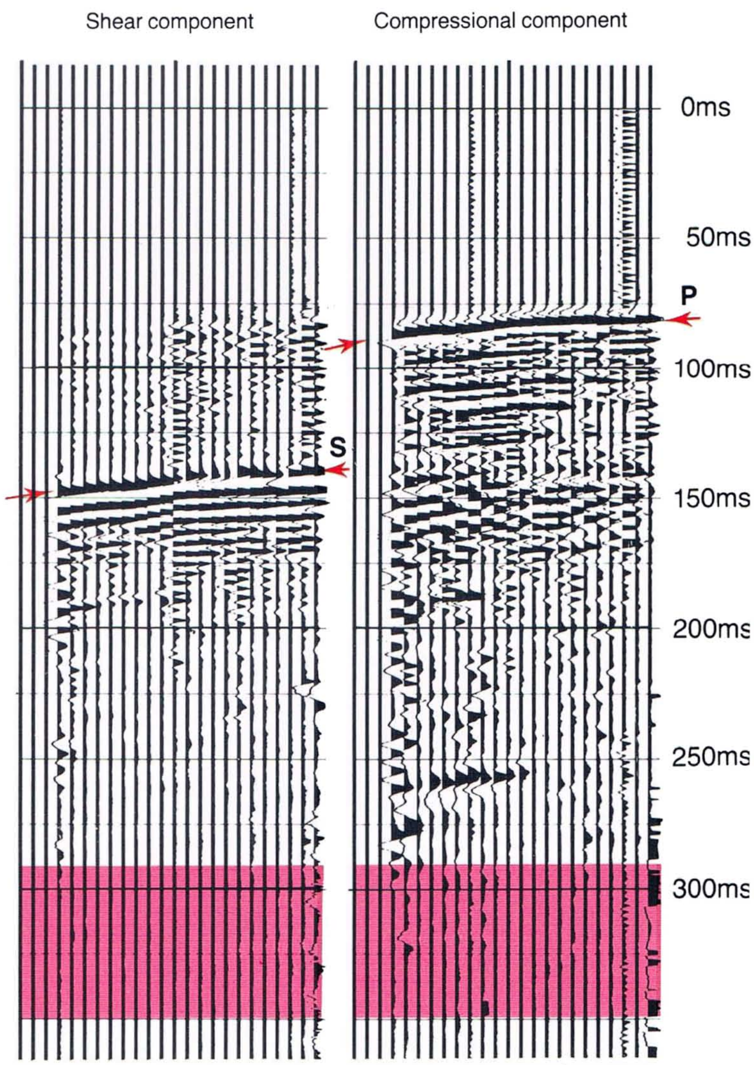


Fig. 8b: Transmission records without channel waves (if present, they would have shown up within the red zone)



The system used for in-seam seismic surveys in collieries with gas hazards fulfills the following demands:

- all the instrumentation is firedamp proof
- high-resolution digital recording with a signal frequency of up to 720 Hz using 24 traces
- low noise level and wide dynamic range of the amplifiers
- no signal attenuation and no frequency losses by using wall clamped geophones
- possibility of applying the roll-along technique (multiple coverage)
- data storage on magnetic tape (1/2 inch tape, format SEG-B, 1600 bpi, PE)
- immediate quality check by paper seismograms
- remote firing, controlled by the system
- telephone communication between shotfirer and operator, independent of the communication system of the colliery
- the complete system is portable and easy to transport.

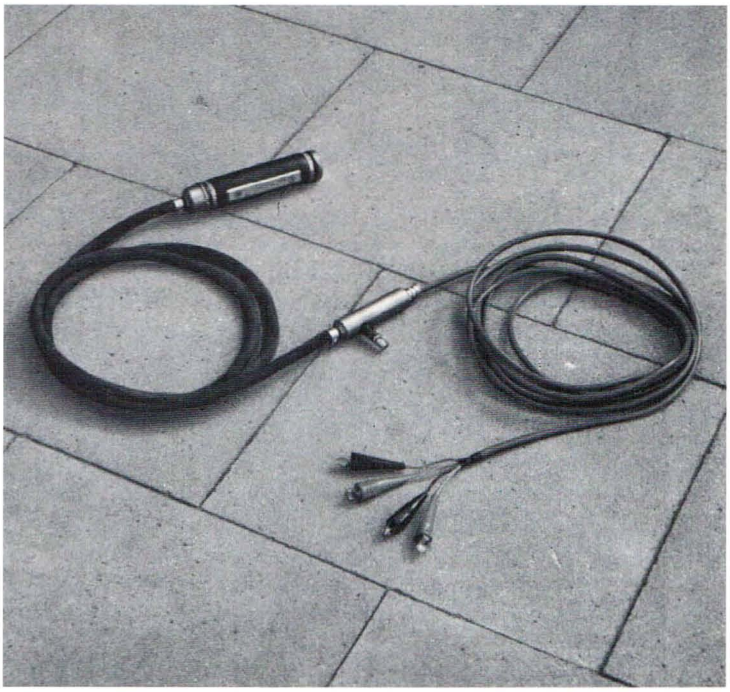


Fig. 10: Wall clamped 2-component geophone

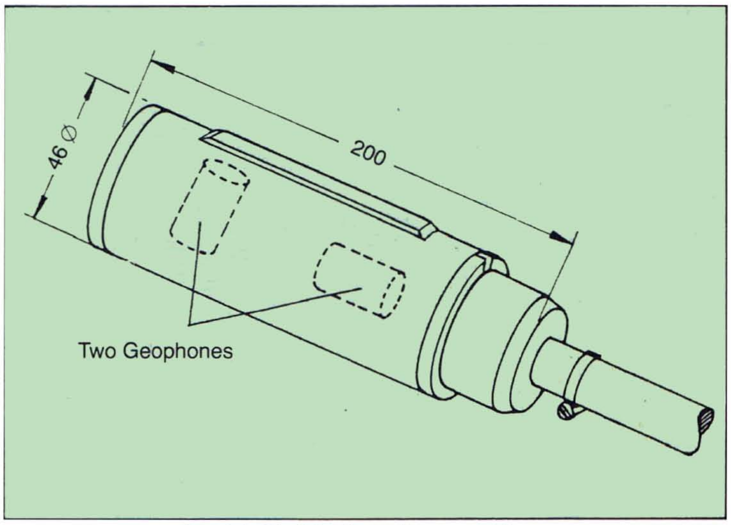


Fig. 11: Sketch of a wall clamped 2-component geophone

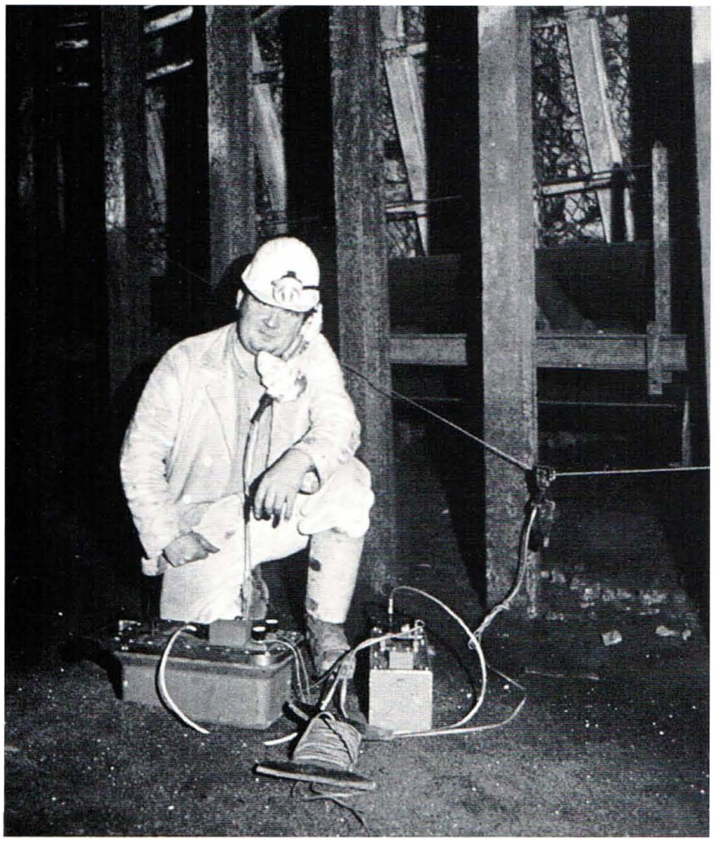


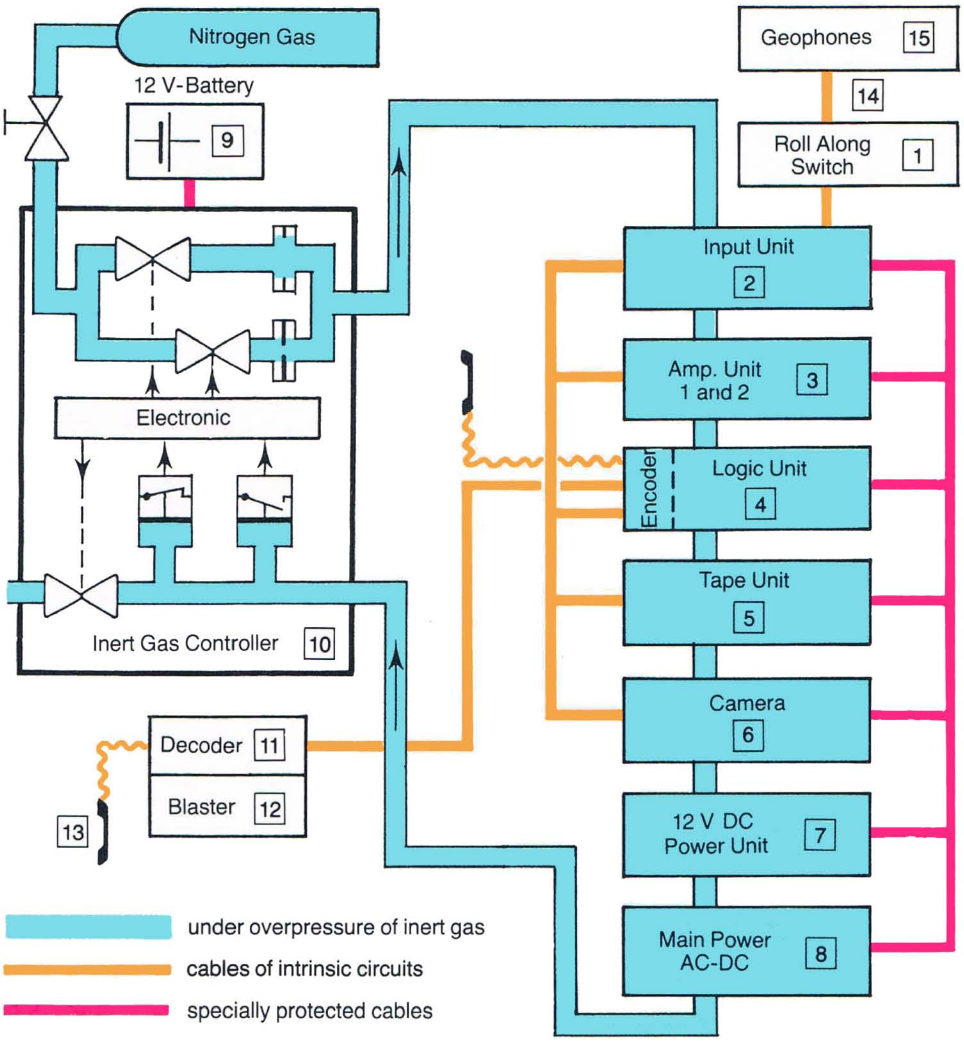
Fig. 9: Shotfirer in action, on the floor the blaster and decoder

Fig. 12: Wall clamped 2-component geophone being put into a 2 m deep borehole

Specifications and Configuration

Fig. 13:
Blockdiagram of the electrical and pneumatic connections

Only when all pneumatic and electrical connections are made the inert gas controller will start the work of scavenging the boxes. Pressure indicators constantly control the flow of inert gas, open and close the pressure valves in order to scavenge the boxes and compensate for the loss of gas pressure. All power supplies will be cut off at the moment the overpressure within the boxes falls below a certain threshold value.



Item	Module	Type of protection*					Size** W x H x D (mm)	Weight (kg)	Quantity
1	Roll along switch				i		634 x 360 x 258	23	1
2	Input Unit			e	i	f	560 x 544 x 700	71	1
3	Amplifier Unit			e	i	f	560 x 544 x 700	61	2
4	Logic Unit			e	i	f	560 x 544 x 700	67	1
5	Magnetic Tape Unit			e	i	f	730 x 544 x 700	86	1
6	Camera			e	i	f	521 x 475 x 475	54	1
7	Power Unit			e	i	f	560 x 394 x 700	51	1
8	Main Power	s		e	i	f	560 x 394 x 650	85	1
9	12 V-Battery		d	e			535 x 255 x 270	49	1
10	Inert Gas Controller		d	e	i	f	634 x 423 x 534	55	1
11	Decoder	s			i		335 x 133 x 173	6	1
12	Blaster	s					470 x 220 x 220	20	1
13	Telephone				i		–	1	2
14	Spread and extension cables				i		–	—	divers
15	Geophones				i		46 ∅ x 200	3	divers

* Types of protections: d = flameproof enclosure (heavy casing); e = increased safety (special precautions); i = intrinsic safety (low electric energy); s = special protection (preventions other than mentioned); f = pressurized enclosure (by inert gas, e.g. nitrogen gas).
** all dimensions with cover and handles

At this time the integrated seismic system is of the type Sercel 338 HR

Technical details subject to change without notice.

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