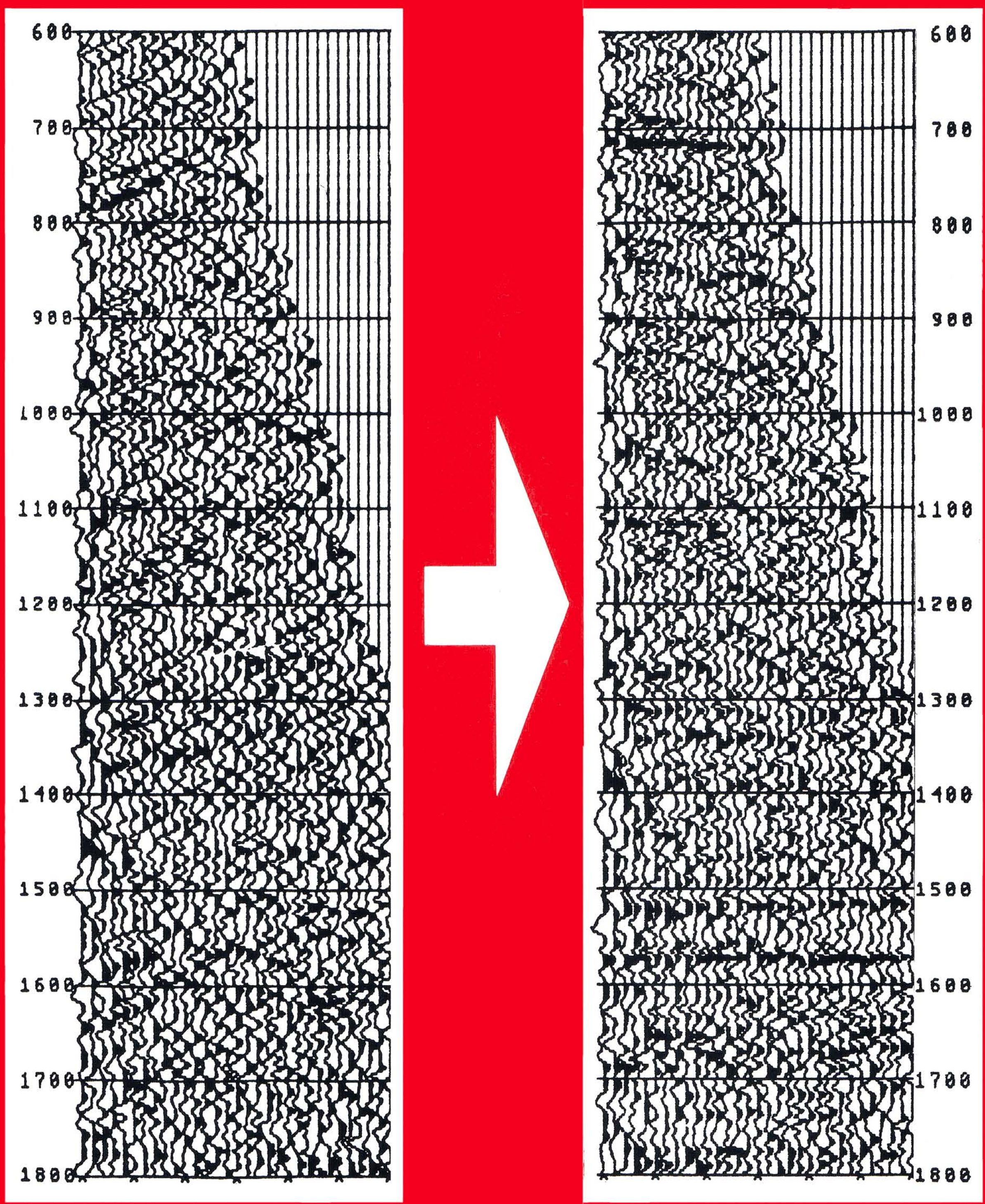
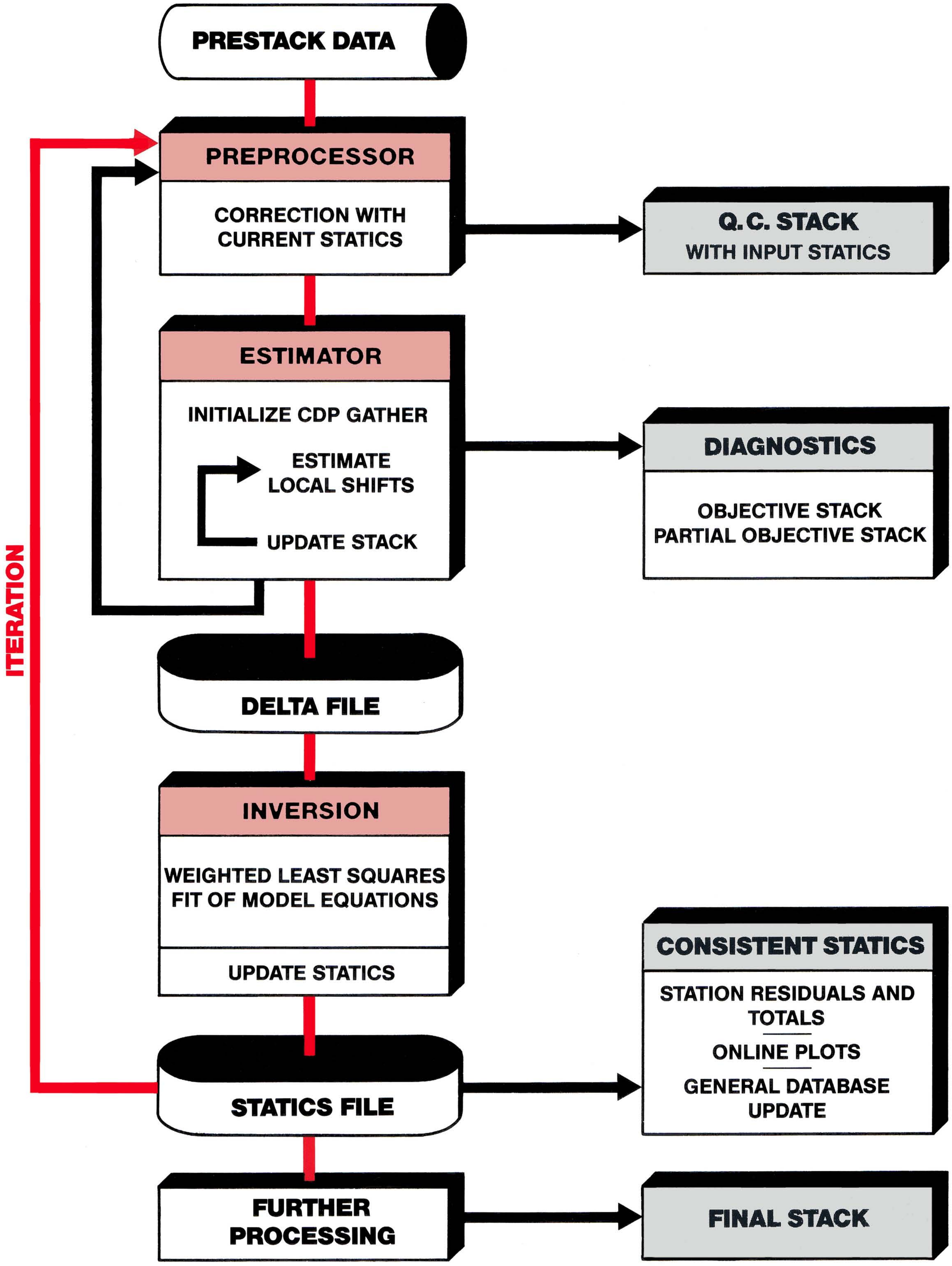
PRAKLA-SEISMOS INFORMATION No. 59

Advanced Residual Statics



GENERAL FLOW DIAGRAM FOR ARC RESIDUAL STATICS



The quality of the static corrections is certainly one of the most critical factors in the processing of seismic land or shallow water data. Poor statics can impair the seismic image in two ways:

1. Short period errors (with wavelengths of up to one spread-length) reduce the stack quality – often to the point at which events get lost. High resolution processing is seriously affected even by very small deviations.

2. Longer period components introduce false structures in the image and may lead to incorrect velocity estimates.

The problem is addressed by providing the best possible field statics, revision by evaluating first breaks or reflection events and a final application of automatic reflection-based residual statics. PRAKLA-SEISMOS offers a wide range of established methods for these tasks. Up to now, residual statics have been achieved by ARSTAT which has shown its value over many years of successful operation. Recent research, however, has led to a new method, **ARC** (**A**utomated **R**esiduals, version **C**), which is even superior to ARSTAT. It is now available as a standard processing procedure.

The basic principle of ARC is **CDP-localized stack optimization,** refer to the block diagram. As with any CDP-oriented method, there are two prominent parts:

A. Estimation of "local shifts" (deltas) which are attributes of the prestack traces. They do not constitute a valid statics solution, but a stack with delta corrections has optimum power.

B. "Splitting", an inversion procedure that converts the deltas into valid surface-consistent station residuals. These are used for updating the current statics file and the resulting totals are input for further iterations of the ARC run, for subsequent velocity analyses or for stacking.

Part **A** is based on iterative optimization of an objective function that reflects the average amplitude of a partial stack to which wavenumber filtering is applied. One sequence of sweeps is carried out for every set of CDP gathers that contribute to a trace of the objective stack. Intermediate stacks with current delta corrections are then formed. As the optimizer sweeps over all single traces, new delta updates are estimated using specific cross-correlations related to the objective function. The intermediate stacks are refreshed immediately. Reliability weights are computed by global evaluation of the cross-correlations. Thus, dubious estimates are detected and bad traces temporarily removed from the stacks. Upon convergence (in 2...12 full sweeps) the final delta totals and weights are filed for step **B.** Now the "objective" trace and the stack of the "leading" CDP gather are output. They supply valuable diagnostics about the ARC run as well as about the status of the velocities and noise related problems. The next CDP gather of preprocessed single traces is read in and a new set of sweeps is initialized.

A file consisting of deltas and weights results from part **A.** The inversion **B** is based on a weighted least-squares fit of the surface-consistent model equations. A conjugate method is used that is an exact equivalent to the SOR solution of the corresponding normal system. Stabilizing constraints are derived from the field geometry as it is impossible to resolve all components by reflection methods; of all the possible solutions the smallest ones are preferred. Systems of millions of deltas can be handled in one run. **This means that also for 3-D data a full-sized areal solution is obtained without any crossline problems.**

Some examples are presented in Figs. 1 to 4. The first is an experiment in which final production data were used as input. Fig. 1a shows a time window of a stacked section. After application of a synthetic static anomaly of some 80 ms, this stack is destroyed, Fig. 1b. Conventional methods using an "external" reference section break down due to the poor initial S/N ratio. Fig. 1c shows the restoration after three iterations of the ARC method. Although power and line-up seem to be even better than in Fig. 1a, there is a slightly tilted block shift in the restored version. As only the very short CDP range of the frames was presented an unusual overlap of short and "ultralong" effects occurs and the shift represents an "ultralong" component not resolvable by reflection methods. The process estimated it as zero. This example demonstrates the power of the method as well as its limitations: Although medium period anomalies are resolved, an estimate of absolute times or very long period statics cannot be expected. As a result, refraction based methods remain indispensable. The front page shows one of the CDP gathers as input data and after the application of ARC. This gives an impression of the single trace S/N ratio and the extent of order introduced in the initial chaos.

The following examples are from actual processing. Fig. 2 shows part of a crossline in a 3-D survey. The brute stack, Fig. 2a, is affected by silts in a recent riverbed. After ARC (Fig. 2b) the situation has improved drastically; note the shallow events. A revision of the field statics based on first breaks was made as a separate check. Using additional ARSTAT residuals the stack shown in Fig. 2c was obtained. It is striking to see how little it differs from the ARC version. On the right hand side the structural effect of ARC is somewhat less than that of the refraction statics as ARC is constrained to prefer a small solution.

The next example, Figs. 3a and 3b shows the power of ARC for cases in which the S/N ratio is rather poor and where coherent noise poses a problem. A definite improvement of the brute stack, Fig. 3a, is seen after ARC application, Fig. 3b. This kind of data really tests residual statics; conventional methods often fail to effect anything at all.

In the last example a comparison is made once again between Fig. 4a, and the stack after ARC, Fig. 4b, and after revised field statics followed by ARSTAT residual statics, Fig. 4c. The problem in Fig. 4a is obvious from the waviness of events and the varying signal strength. After ARC the stack appears smooth and of high quality. The version with revised field statics confirms the structural aspect of the ARC solution, as attested by the events at 620 ms.

The merits of the ARC method:

1. **Ability to handle comparatively large shifts – up to ± 40 to ± 120 ms within one CDP gather.**
2. **Resistance to cycle skipping, residual NMO and coherent noise.**
3. **Excellent high resolution statics if final iteration with small search range (± 20 ms) is used.**
4. **Medium period anomalies (up to 2 spread lengths) are effectively resolved.**
5. **Unified areal solution even for the largest 3-D surveys.**
6. **Extensive diagnostics including indications of velocity and noise problems.**

CONTROLLED EXPERIMENT

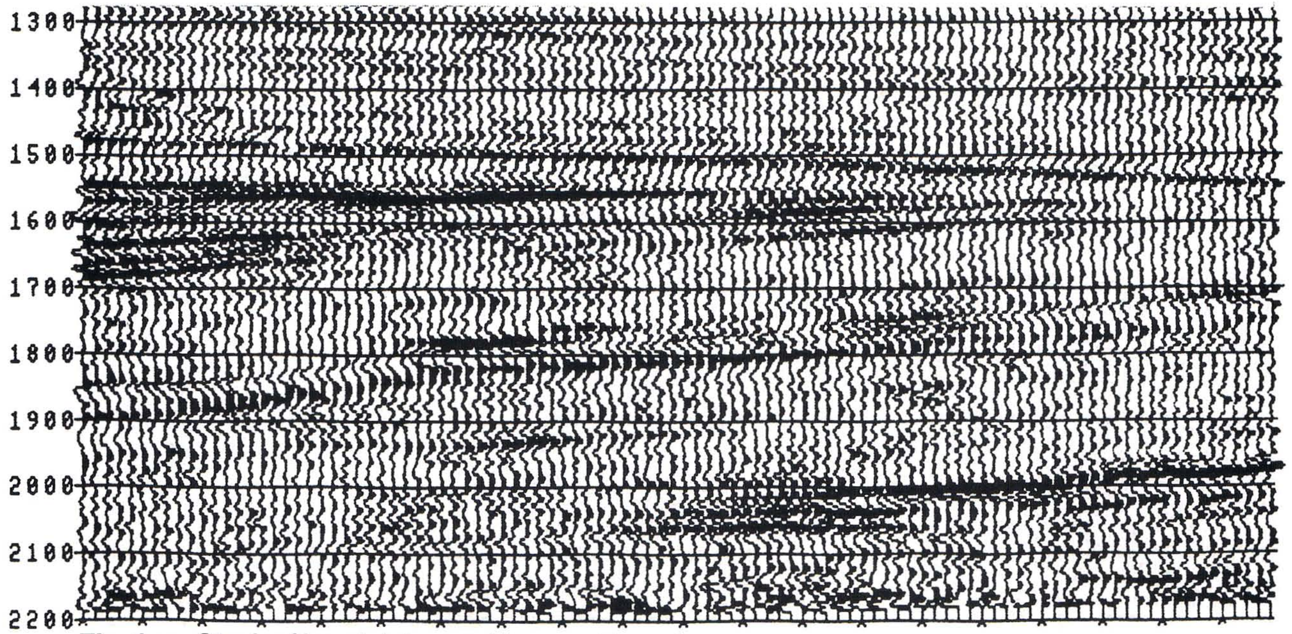


Fig. 1 a: Stack of input data used for experiment

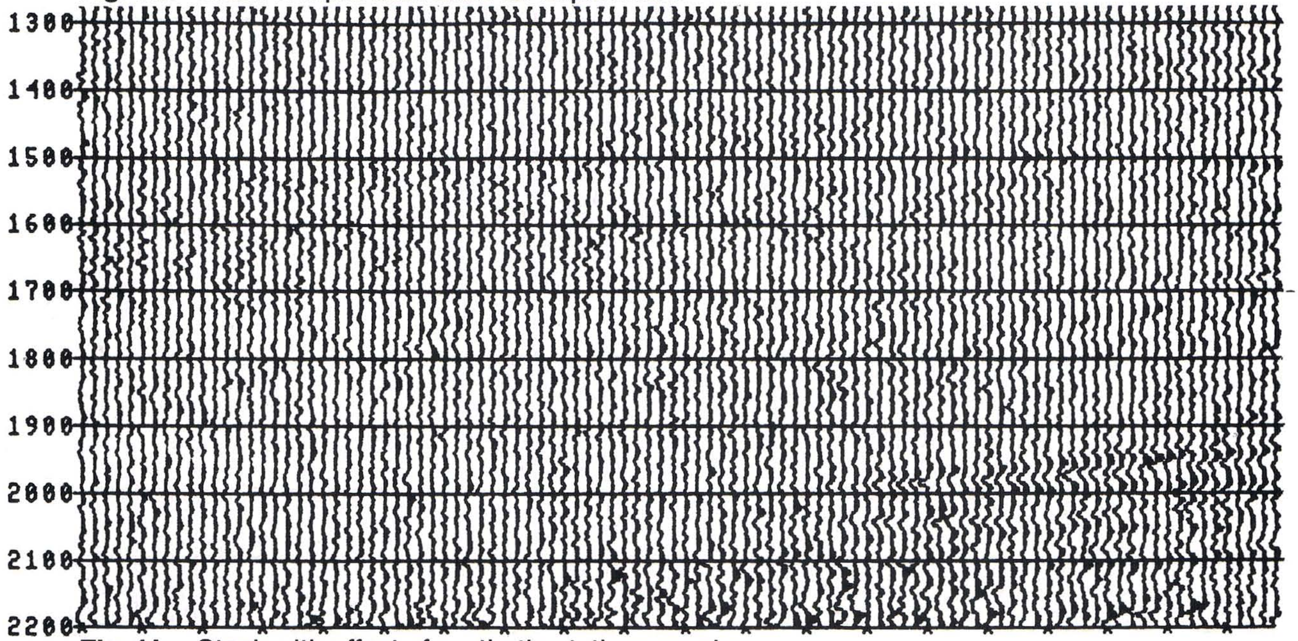


Fig. 1 b: Stack with effect of synthetic static anomaly

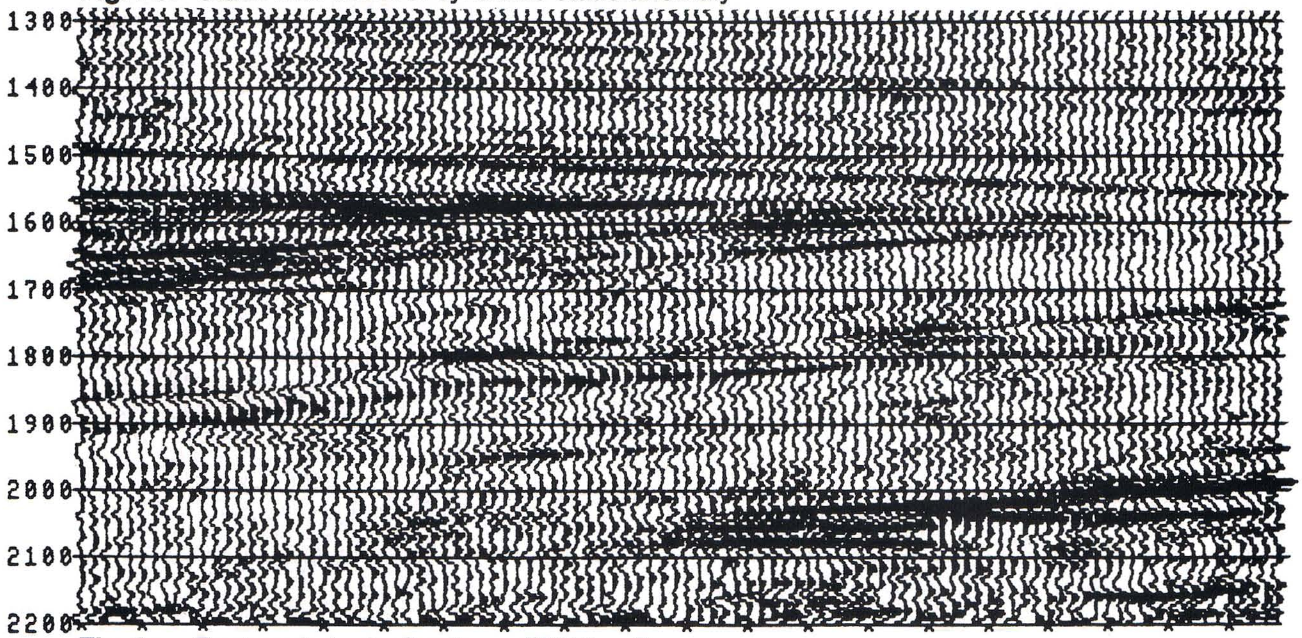


Fig. 1 c: Restored stack after three ARC iterations

Part of a crossline in a 3-D survey

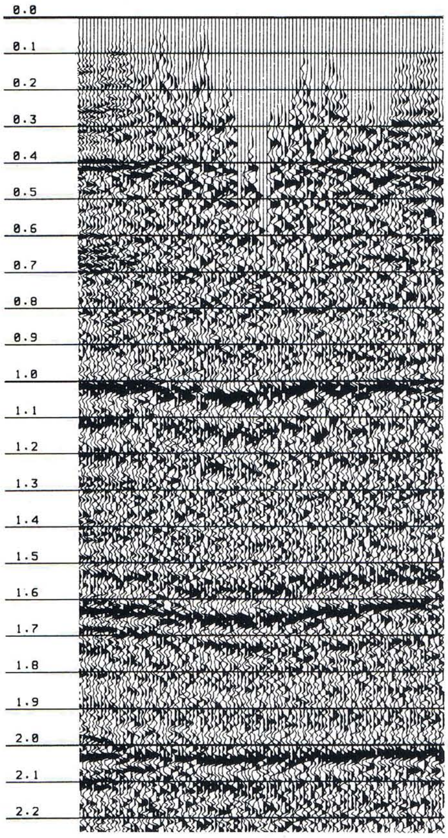


Fig. 2a: Brute stack

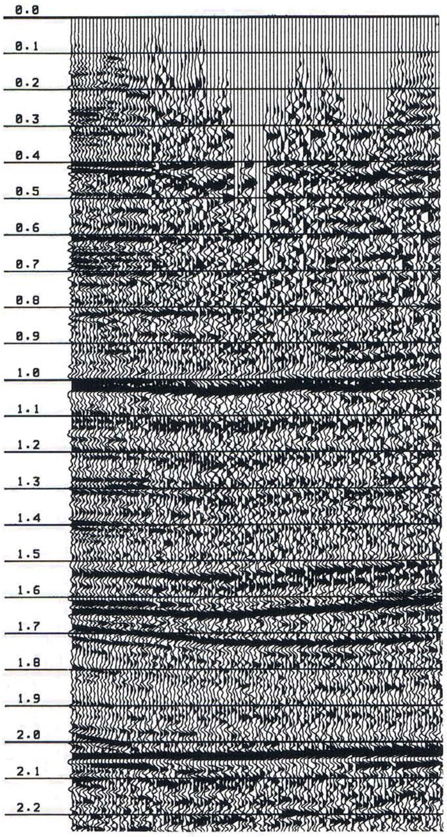


Fig. 2b: Stack after ARC

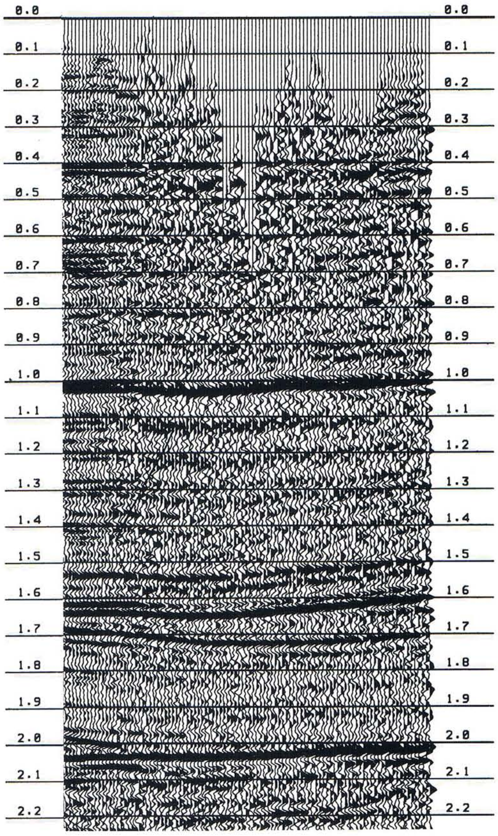


Fig. 2c: Stack with field statics revised by first breaks followed by ARSTAT residuals

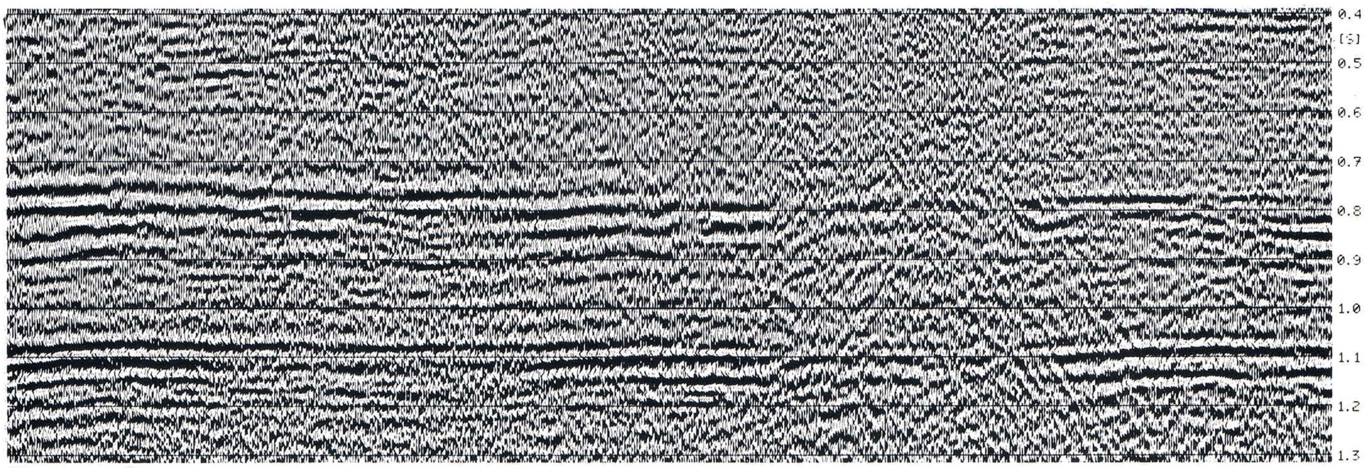


Fig. 3a: Brute stack

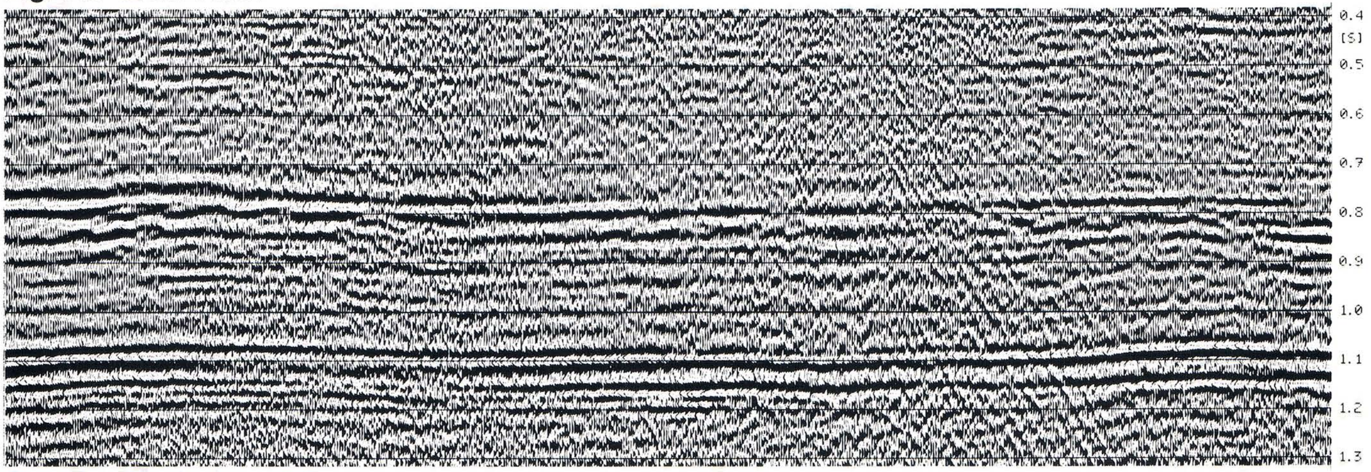


Fig. 3b: Stack after ARC

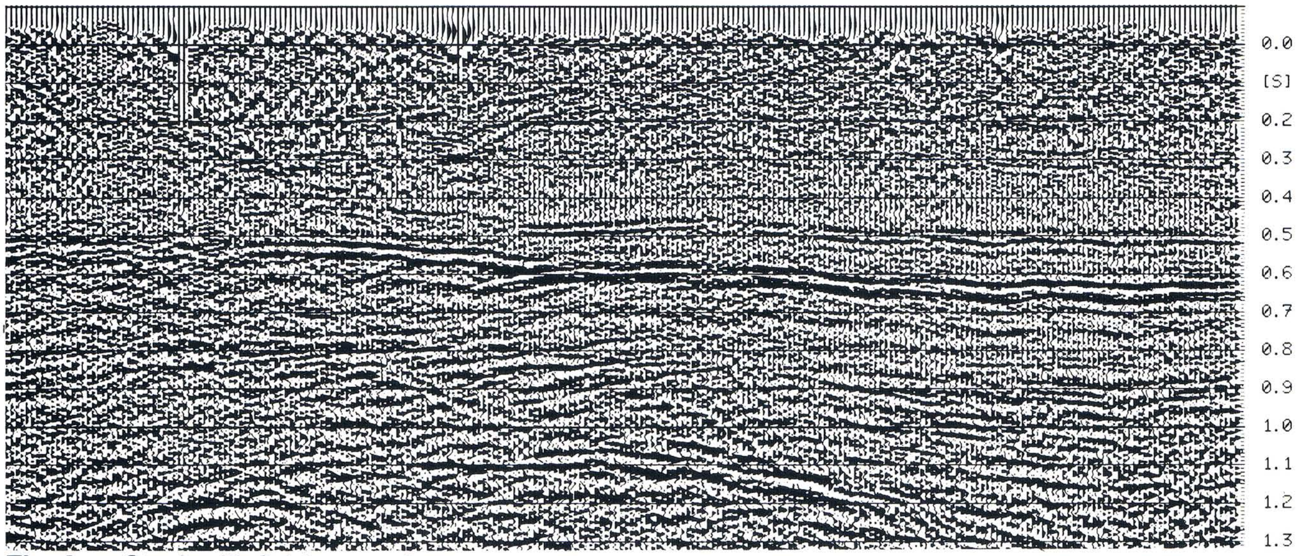


Fig. 4a: Stack with field corrections

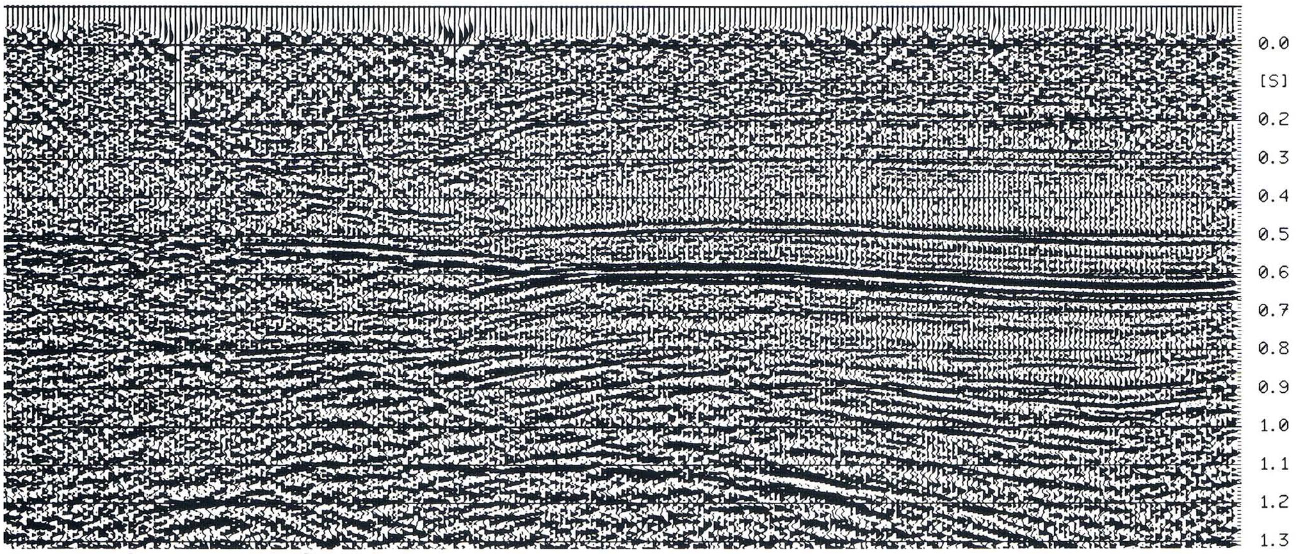


Fig. 4b: Stack after ARC

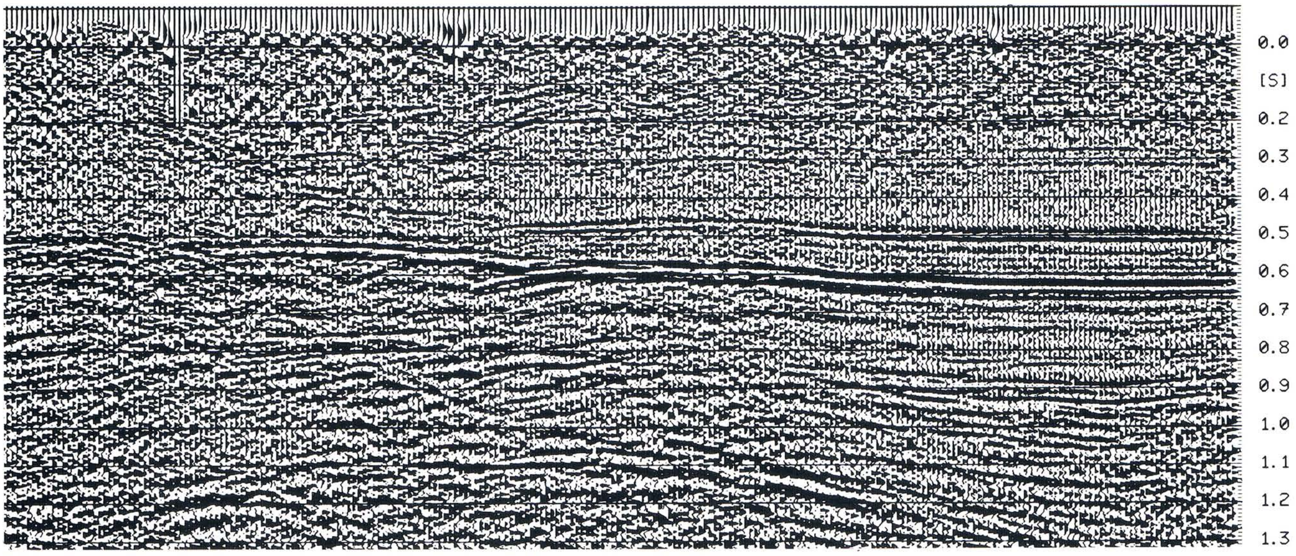


Fig. 4c: Stack after revised field statics followed by ARSTAT residuals

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