A proposed algorithm for picking events in CMP gathers

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ABSTRACT

Can a program imitate the human eye in picking hyperbolic events in a CMP gather in an exhaustive way? Can this be done better and/or faster than using NMO and stacking? How meaningful is improving stacking velocity analysis?

INTRODUCTION

Let us accept the following seismic model: reflections from a series of flat horizontal and/or dipping layers should appear as hyperbolic events in a CMP gather. Trying to write a program that would automatically "pick" those hyperbolic events (and their corresponding stacking velocity) I realized that to identify an event there are several ways:

- find its pieces in each trace and then choose those that (almost) form hyperbolas
- choose hyperbolas and try to find pieces in each trace that (almost) fit them
- choose hyperbolas and sum the data on them to see how much energy you get

I decided to follow the first way. So I have to answer the following question.

How to choose pieces of a trace that are possible members of an event?

The interpreter would consider those pieces of the trace whose samples have amplitudes large enough to distinguish them from their neighbouring samples. This is equivalently expressed as a satisfactory SNR or as greater energy carried by this piece of the trace.

Paulson and Merdler(1968) used the local maxima of the trace but they "picked" data stacked and processed for SNR enhancement.

The sign bit semblance method (Cochran, 1973) and coherence techniques using similarity measures like crosscorelation or the Simpson similarity measure in Quincy (1986), use the information about lateral coherence in adjacent traces.

The pattern recognition techniques use either a definite criterion for the classification in one trace (Gaby, 1983) or a whole a priori definition of a test wavelet to be matched with the data (Anderson, 1983).

The question that follows then is:

How to define and look for lateral coherence?

The locations of events in a CMP gather should be hyperbolic if we didn't have the following factors affecting our experimental results:

- non-flat beds
- incoherent noise
- coherent noise
- statics
- multiples

Because of the incoherent noise and the statics the reflections from actual horizons are "fuzzied", while coherent noise and multiples present themselves as events while they are not.

From the references of the previous paragraph most do not confine themselves in CMP data and thus do not take the information about "fuzzy" hyperbolas into account (Paulson, 1968 and the PR methods). Cochran (1973) follows the classical procedure for stacking velocity analysis.

THE PROPOSED ALGORITHM

The automatic picking program should do the following:

1. detect events in each trace of the CMP gather
2. link together in a dynamic list those that lie on "fuzzy" hyperbolas recursively so that it can chop off any non-hyperbolic path that the list might follow (such as coherent noise)
3. do the second step interactively

4. indicate that some of the lists are possible multiples of another

I have started out experimenting with alternative solutions for the problems that appear in each step.

RESULTS FROM THE FIRST EXPERIMENTS

So far I have decided to use the following definitions.

location of an event in a single trace is defined as a local maximum (peak) on the trace.

event in a CMP gather is defined as the set of peaks that lie "almost" on

$$t^2 = t_0^2 + x^2/v_{stacking}^2$$

where "almost" has to be defined too.

stacking velocity is defined to be the velocity in the denominator of the previous equation.

The third definition needs no discussion if we agree not to concern ourselves with its physical meaning and practical value for the moment. The second definition is yet incomplete and "almost" has to be defined to incorporate the "fuzziness". The first definition is based on the interpreter's view and the reasons for using it are explained below.

Location of an event in a single trace

Having in mind to use a cumulative sum algorithm to detect an energy burst in the trace which would qualify as an event I needed either to estimate the statistical properties (i.e. variances) of the various low and high energy areas of the trace or to simply compute them.

Assuming that the trace is everywhere zero mean I replaced each sample of the trace with the variance that I computed in a window centered on the trace. This way I hoped to get the variances I needed and a smoothing analogous to the one provided by the classical stacking procedure. Part (c) of Figures 1 to 5 show the result of this for the gathers shown in part (a).

Deciding that this leads to too much loss of detail I then used the local maxima in the trace as the starting locations of events. All the samples except the local maxima of each trace are zeroed. Result of the application of this process to the gathers in part (a) of Figures 1 to 5 are shown in part (b) of each Figure.

Comments

Some of the Figures show encouraging results and others not so. The course of action that I plan to follow now consists of

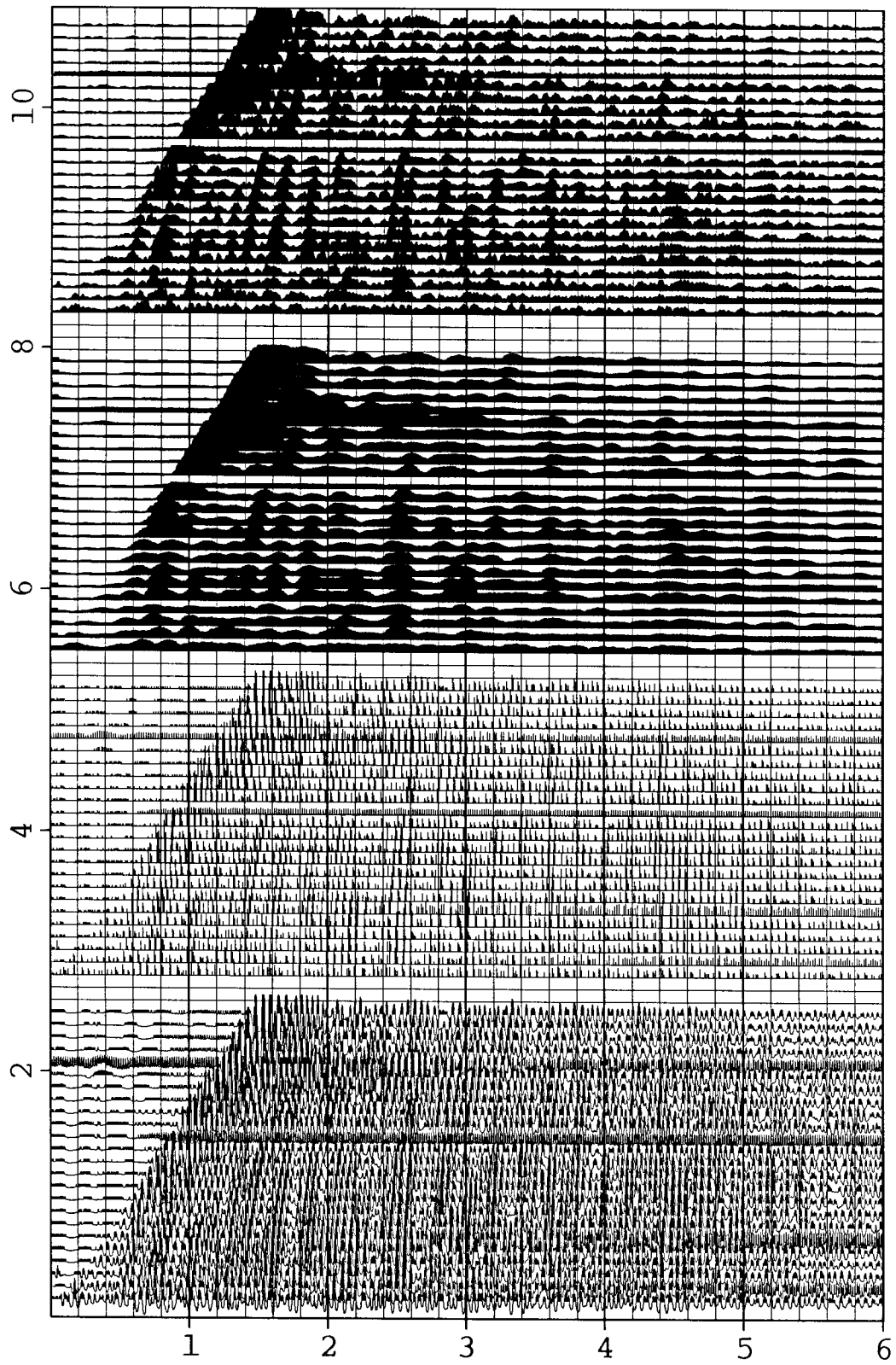

FIG. 1. (a) Gather # 3 from Yilmaz, (1983) — Land survey,Alog(Dyn). (b) The result of zeroing all samples except from the local maxima. (c) The result of replacing each sample with the variance of a window of 25 (left) and 5 (right) samples centered on it and lying on the same trace.

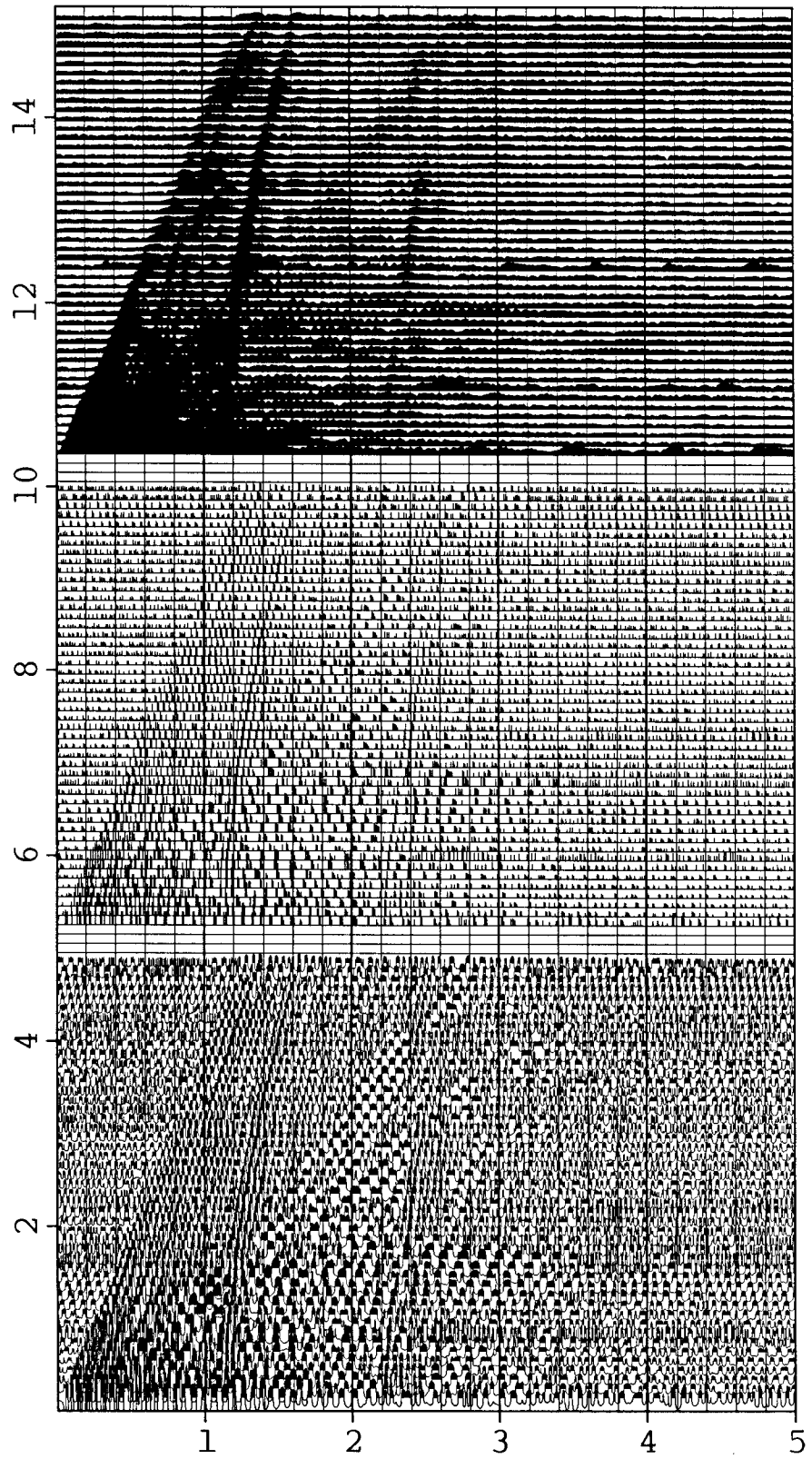

FIG. 2. (a) Gather # 6 from Yilmaz, (1983) — Land survey,Dynamite. (b) The result of zeroing all samples except from the local maxima. (c) The result of replacing each sample with the variance of a window of 5 samples centered on it and lying on the same trace.

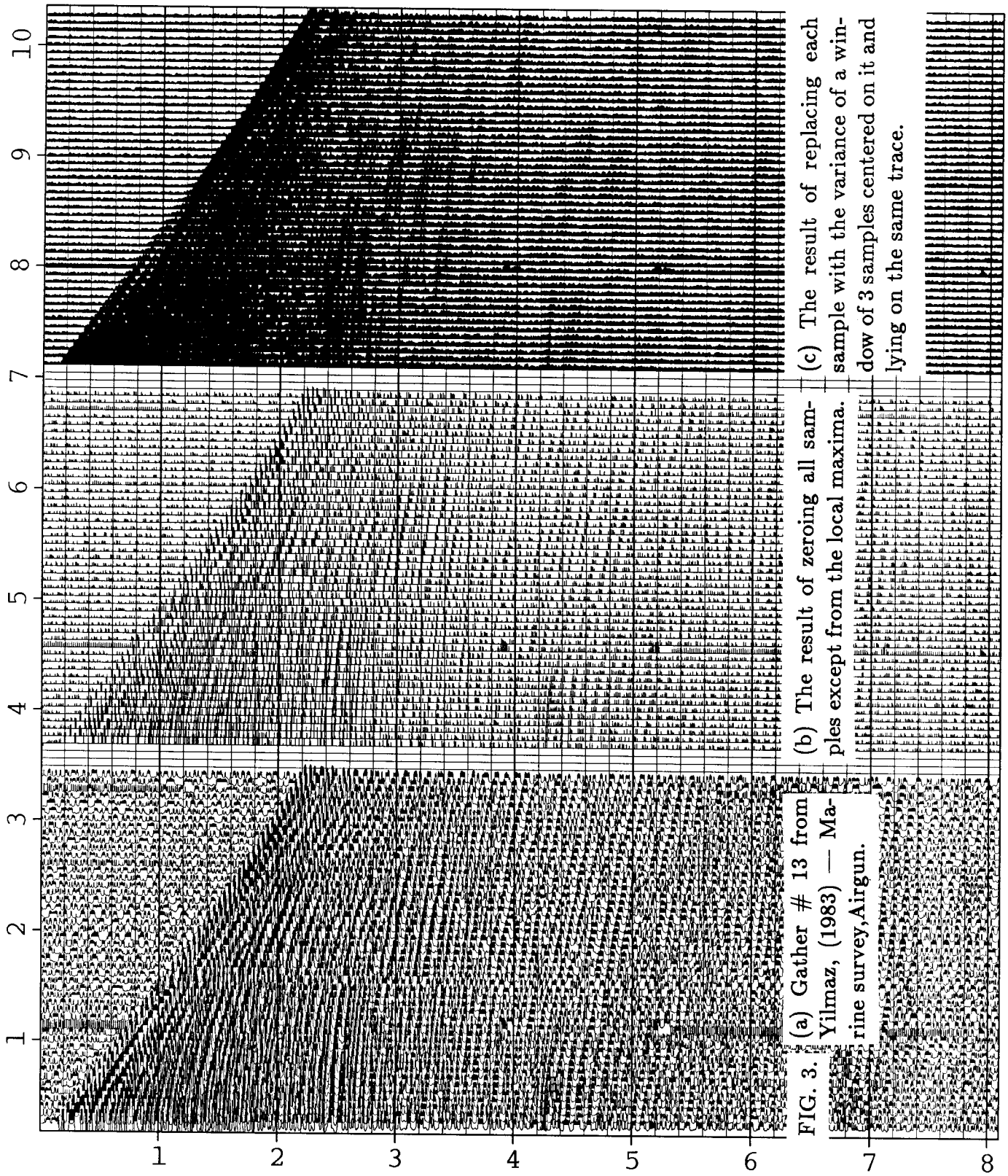

FIG. 3. (a) Gather # 13 from Yilmaz, (1983) — Marine survey,Airgun. (b) The result of zeroing all samples except from the local maxima. (c) The result of replacing each sample with the variance of a window of 3 samples centered on it and lying on the same trace.

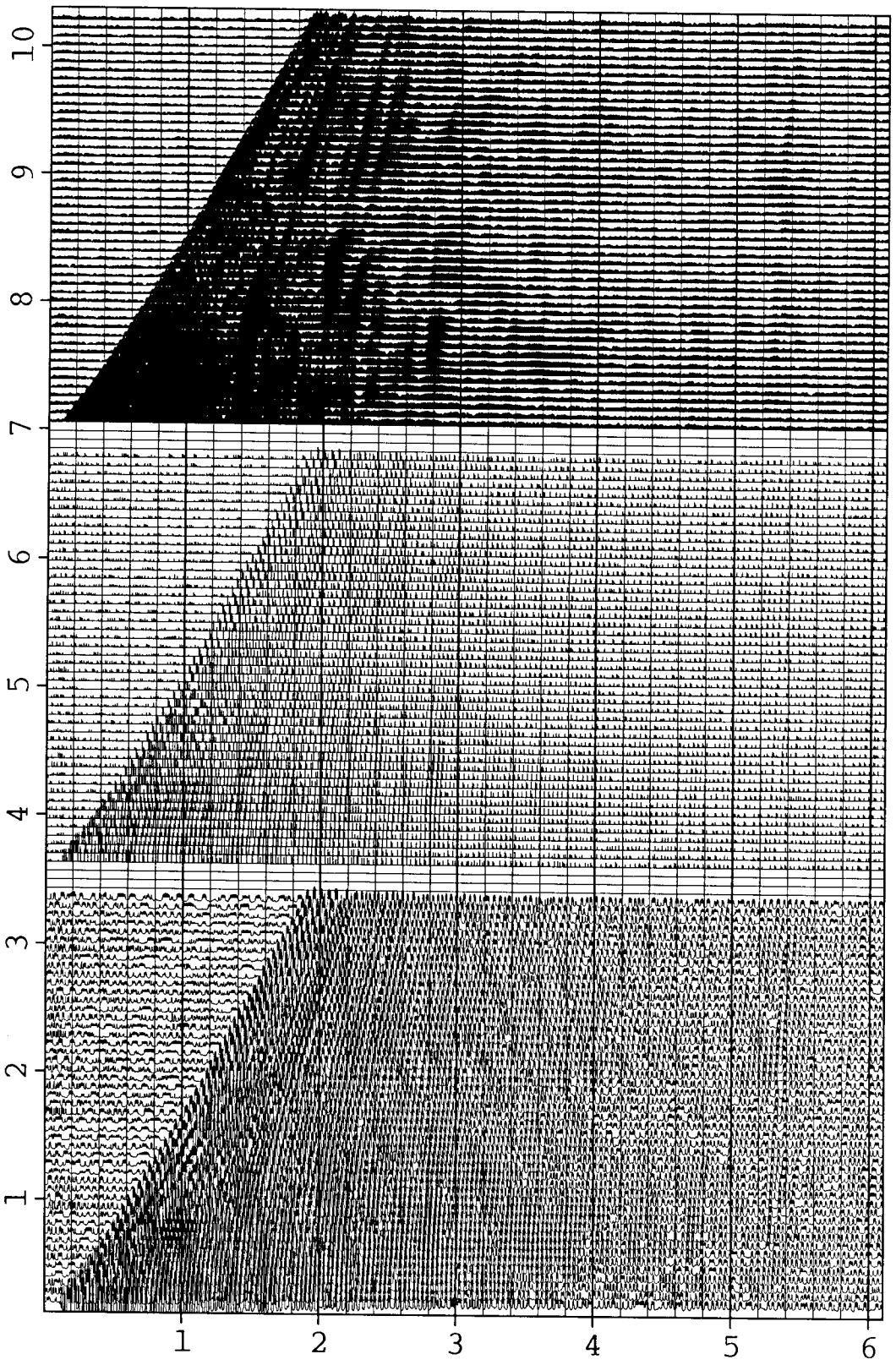

FIG. 4. (a) Gather # 14 from Yilmaz, (1983) — Marine survey,Aquapulse. (b) The result of zeroing all samples except from the local maxima. (c) The result of replacing each sample with the variance of a window of 3 samples centered on it and lying on the same trace.

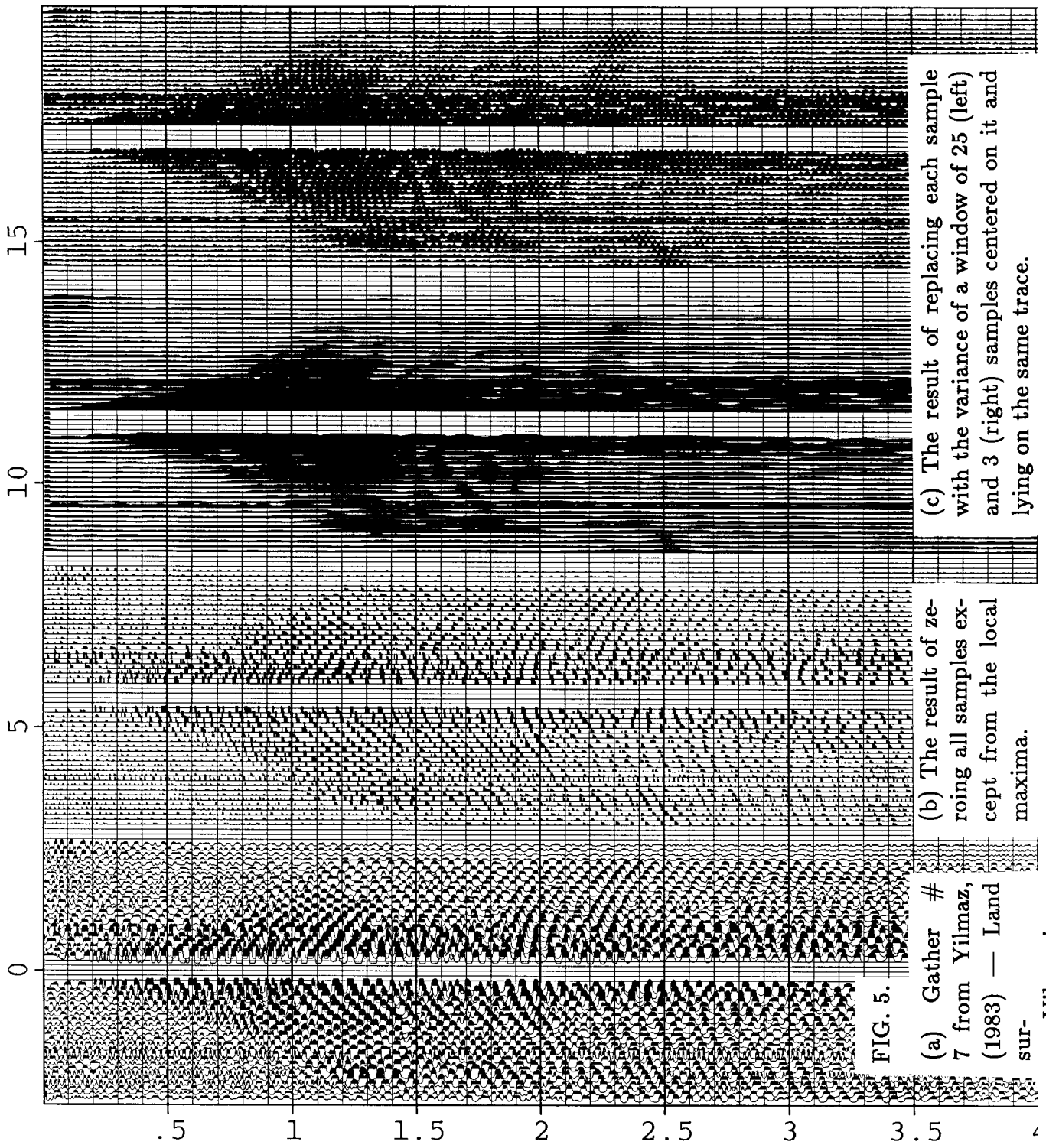

FIG. 5. (a) Gather # 7 from Yilmaz, (1983) — Land survey,Vibroseis. (b) The result of zeroing all samples except from the local maxima. (c) The result of replacing each sample with the variance of a window of 25 (left) and 3 (right) samples centered on it and lying on the same trace.

- finish the program that "picks" local maxima that lie on "fuzzy" hyperbolas
- refine the definition for the location of an event in a trace by using more wavelet carried information (perhaps using pattern recognition)
- compare performance with that of stacking velocity analysis of various packages

REFERENCES

Anderson, K. R., and Gaby, J. E., 1983, Dynamic waveform matching, Proceedings of the 3rd International Symposium on Computer Aided Seismic Analysis and Discrimination, IEEE Computer Society.

Claerbout, J.F., 1987, Datum shift and velocity estimation, SEP-51.

Cochran, M.D. 1973, Seismic signal detection using sign bits, Geophysics 38, 1042-1052.

Cordier, J.P., 1985, Velocities in Reflection Seismology, D. Reidel Publishing Company.

Gaby, J.E., and Anderson, K.R., 1983, Using affinity to derive the morphological structure of seismic signals, Proceedings of the 3rd International Symposium on Computer Aided Seismic Analysis and Discrimination, IEEE Computer Society.

Paulson, K., and Merdler, S., 1968, Automatic seismic reflection picking: Geophysics 33, 431-440.

Quincy, E., and Tomich, D., 1986, Image processing of seismograms using two-dimensional coherence techniques: Pattern Recognition and Image Processing, edited by F. Aminzadeh, Handbook of Geophysical Exploration, Section I. Seismic Exploration, Volume 20.

van Trier, J., 1986, Velocity analysis by non-linear optimization of phase-contoured shot profiles, SEP-51.

Yilmaz, O. and Cumro, D., 1983, Worldwide Assortment of Field Seismic Records, released by Western Geophysical Company of America, Houston.

Los Angeles Times

Muscovites Gawk as U.S. Opens High-Tech Exhibit

By WILLIAM TUOHY, *Times Staff Writer*

MOSCOW—There was much to gawk at Thursday, and Soviet citizens gawked—at personal computers, a Plymouth Voyager van, a supermarket checkout counter, a do-it-yourself device for checking blood pressure and videotapes of space shots and a Super Bowl football game.

It was opening day of the first official exhibit since 1979 to result from a Soviet-American exchange program, a presentation by the U.S. Information Agency called "Information USA—Linking People and Knowledge."

The idea is to show the Soviets how Americans benefit from communications technology and information systems, in schools and offices, on the farm, in factories—just about everywhere.

Wick Opens Exhibit

The exhibit was opened by USIA Director Charles Z. Wick, who arranged for President Reagan to deliver a welcoming message by videotape, simultaneously translated into Russian.

In return, a Soviet exhibit will tour the United States later this year.

The first such exchange between the two countries took place in 1959 and led to the famous "kitchen debate" between Vice President Richard M. Nixon and then-Soviet leader Nikita S. Khrushchev.

Many facets of American life are being displayed by the high-tech equipment, but the job is probably being done even better by the Russian-speaking Americans who have come with the exhibit. They will tour with it for the next 18 months as it moves from Moscow to Leningrad to Kiev, Rostov, Minsk, Tbilisi, Tashkent and Irkutsk.

Ready for Questions

The 14 women and 10 men serving as guides are all prepared to answer questions about the exhibit and about American life in general.

They are also expected to learn a great deal about the Soviet Union and its people, ordinary citizens whose views are not normally available.

"I'm really looking forward to this year," said Michael Malara, 29, a Californian who lives on the Palos Verdes Peninsula. "I think the Russians and the Americans have a lot to learn from one another."

Malara has a degree in Russian studies from USC and a master's degree from New York University. He studied Russian at Moscow's Pushkin Institute in 1984 and 1985.

He shows people at the exhibit how computers can be used to make designs and blueprints, and he allows them to print out their creations as souvenirs.

"I'm used to being asked questions about America," he said. "Russians do know something about the U.S., but it's pretty much one-dimensional. They like to know what things cost, how much you pay for a car, an apartment, a color television set—and about whatever larger issues are currently being played on Soviet television concerning America.

'Russians Fascinated'

"I have found Russians fascinated about American life, and I try to give them an accurate but rounded picture. Right now, there's a lot of concern about AIDS here because there is so much about American problems with the disease on Soviet television."

Standing behind the checkout counter was Janice Eklund, 25, of Bloomington, Ind., a Russian specialist with degrees from Indiana University and Bates College at Lewiston, Me. She was showing Soviet visitors how computers serve as cash registers, with optic scanners that read the coded prices on cans and bottles and packages.

"I'm a little nervous," she said. "It's my first day, but I think it will be a lot of fun, especially here at this food stand."

No Peanut Butter

But a senior official from the Foreign Ministry, Gennady I. Gerasimov, who spent five years in New York City working for a Soviet news agency, said later with a smile:

"I went up to the stand and asked for one of my favorite foods—peanut butter. And she said blushingly, 'We don't have any.'

"I said, 'What kind of an American supermarket is this?'"

Charles Strouse, 28, a writer from St. Paul, Minn., said he thinks "this is a helluva way of getting around the Soviet Union."