SOME PROBLEMS INVOLVED IN SEISMIC DATA PROCESSING*

By

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In a paper to the C.S.E.G. in 1956, D. C. Skeels made the observation that "much of what passes for seismic interpretation is really computation, with little reference to geological data." A paraphrase of that remark is appropriate now; to wit—much of what passes for seismic data processing is really manipulation with little reference to geophysical, much less geological, data.

With "Data Processing" we have added another potential barried between our field observations and intelligent results. It *can* be a formidable barrier. One of its languages is mathematics, the math. that most of us, with a sigh of relief, left behind at university; if we encountered it at all. Dr. Skeels went on to say that we need people to "corrolate geophysics and geology," "people who understand the language of both professions." Over the past years we have added several languages, and professions, in our attempts to find oil and gas, and it is equally important that we be able to communicate with these new people. Some people think we have trouble with two languages in this country—they ought to spend some time in a data processing centre.

In a nutshell then our problem is communication. Communication between the geologist and the interpreting geophysicist; between this man and his mathematical and electronic cohorts. This problem has actually been around since the beginning of geophysical exploration. Its magnitude, however, has increased sharply over the last 10 or 15 years with the increased sophistication in the mathematical analysis of geophysical phenomena, and, in the gathering and processing equipment. It is a mistake to think that digital processing is responsible for all this —it merely opens the door to practical solutions for problems we knew existed, but, since there was nothing we could do about them, we could easily ignore them.

The prime requisite for effective communication is a common language. Since this is almost impossible we must take great care with the words we use. The A.S.P.G. controversy over the pronunciation of nomenclature is a classic example of how to get fouled up before you start. A few years ago when an interpreter asked for a wiggly trace and variable density section it was a toss-up whether he wanted one section or two. We have got over a certain prudishness now, and most people call the combination a VD/galvo section. Fortunately squiggle has gone the way of all flesh—but at least there was no doubt there.

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When is a Fi really Hi? — or similarly when is Deconvolution really that? Until we know a lot more, or become magicians, shouldn't we call it partial deconvolution. However, calling a record player Lo Fi is never going to sell it. Can you imagine listening to the Western Hit Parade—good up to 20,000 cycles?

Do we all know what we mean by trace and channel? The analog and *some* of the digital channels are the same and yet different, and in analog alone the trace and the channel are the same until you get to the tape—then look out. How many bits make a byte, and is a digital record the same thing as a geophysicists record? That last one can lead you down the garden path.

Unless we are very careful with our words we could find ourselves in a very sticky situation.

The lack of communication within geophysics has led to a separation of data processing, field procedures and interpretation. Not only do we have four languages, but we've got separatists as well! The results of this separation create many problems that come home to rest in the data processing centre.

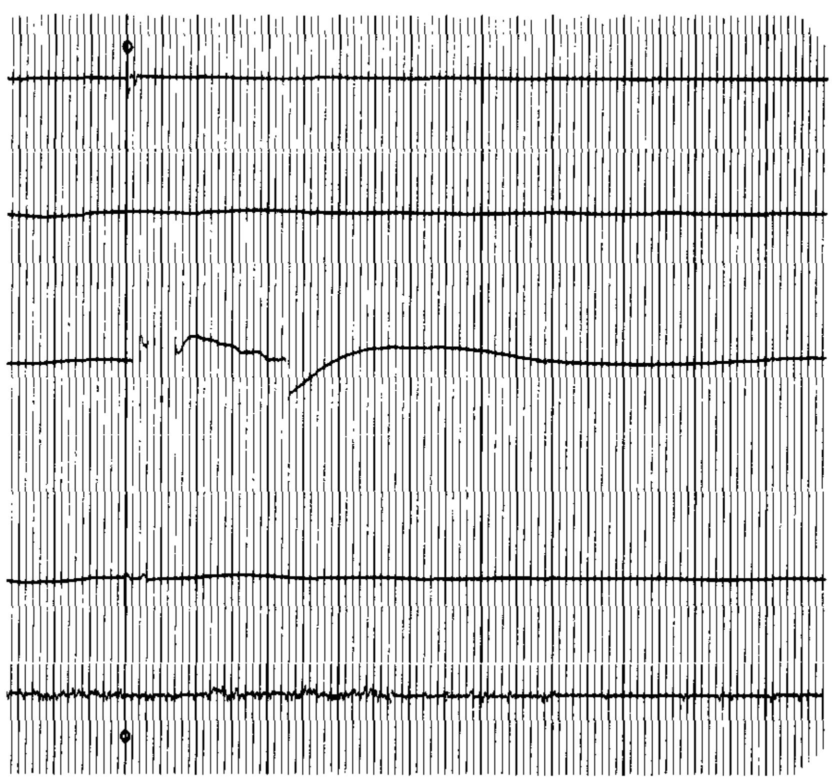

FIG. 1.—Five samples of time break received at data processing centre.

One thing we fail to realize about data processing is that it starts with the shot; or, if you will, the time break. We record that time break so we can process our data. Everything we do, from weathering computations to picking reflections and playing back cross sections hangs on that time zero; and yet this piece of data is probably recorded with the least fidelity of anything on our tapes. It is often a real challenge to a processing centre to find the time break on some tapes. If the operator guesses wrong, and the data is marginal, it is just about impossible to catch the mistake. While poor time breaks are a serious problem, it is astonishing how often no time break is recorded at all. On occasion a whole day's shooting and sometimes more is recorded this way. Fig. 1, with a reasonable time break at the top, is a sample of the sort of thing run into every day in a data processing centre. On traces 2, 3 and 4 the breaks are .003+ secs. ahead of the 0 line. It may not be visable but trace 2 does have a time break. Either break on trace 4 could be time break, and trace 5 is anybody's guess.

While the time break controls our starting point, the timing of the rest of the record is controlled by a timing signal, recorded (most of the time) on the tape. It is possible to wire some instruments so that a playback record in the field will have what appears to be a timing signal on it, while there is none on the tape. Until the tapes are played back on another device no one is the wiser. There will always be sleepy operators letting the occasional out of sync. tape get by, but unfortunately timing problems, when they occur, often go on for days before they get caught. Both the time break and timing require constant vigilance, and no one can afford to slack off for a moment in this department. To monitor the timing signal from every tape processed is a deadly job, and as a result some errors get by—but it is a job that must be done. Two out of sync. tapes in one stack, if they are not too far out, could produce a very interesting anomally and a very dry hole. In other words look at the time breaks and the timing before you show off the section. This could save considerable embarrassment and money.

While the two mentioned are primarily control factors, we do appreciably process our data in the field with shot hole and geophone arrays. Unfortunately there is very little experimenting done to determine the best combination of holes and geophones and their separation. On many an occasion the selection of cable length and hole location seems almost capricious. This is especially true of common depth point shooting where the depth of the section and the desired results do not seem to have played any part in the selection of field procedures. It is true that equipment availability and economics govern what can be done, but quite often it is a matter of taking the easy way out. In the case of common depth point shooting the increased number of shot points needed has often led to the cutback in the number of holes used per shot. This results in poorer data and less accurate corrections. Some of this is rectified by stacking in the data centre but more often it is a case of two steps forward by using C.D.P. and 1.9 steps backwards by lowering the quality of the original data.

Another kind of separation, that between instrument manufacturers, has caused considerable headaches. Figure 2 shows most of the different types of analog tape used to record seismic data. With one minor exception, they are completely incompatible. The situation looks a little brighter in the digital field. At present there is a 1 inch 21 channel tape, a half inch 7 channel and a half inch 9 channel tape. It is not all smooth sailing yet. It has been estimated that there are 54 different ways of recording the data on that ½ inch tape, and so far 14 of these

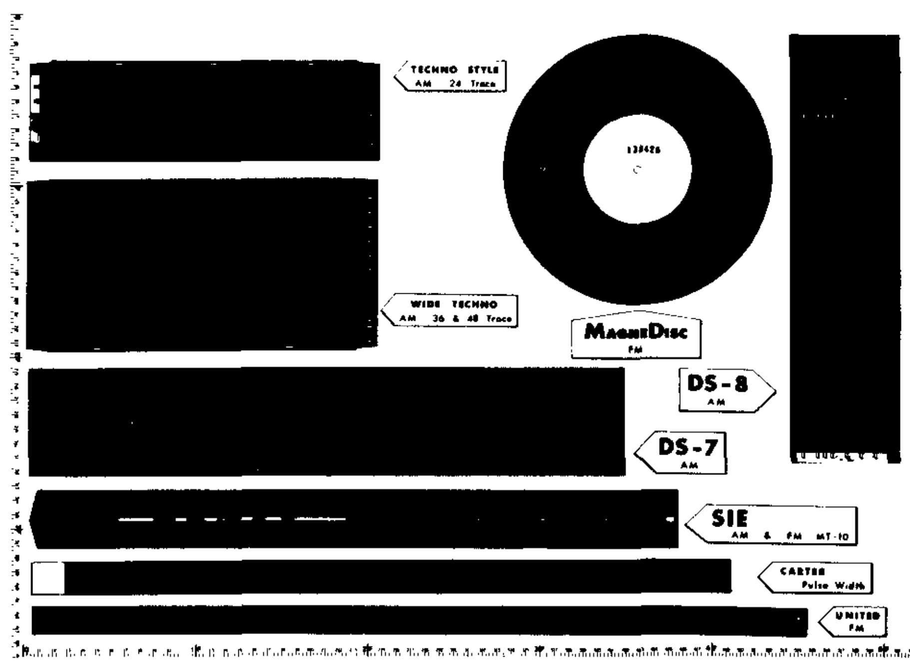

FIG. 2. -Geophysical tapes in common use.

are being used. To date, the number of bits per inch has stayed the same—but that could change. Fortunately these varieties will not require to much separate hardware, but there will be some furious input program writing going on.

If we have learned anything from the new shooting procedures, particularly those using long spreads, it is that we do not know enough about the velocities in this country. The time was when a person worrying about velocity was trying to tie seismic coverage to wells. Now if we are to make sections or, of even more importance, stack the data, we must correct for the normal move out. The analog equipment currently in use can do a fair job of making this correction, and the digital can do an excellent one—provided they are fed the right information. The normal move out varies, more or less, as the inverse of the average velocity squared and it doesn't take too great an error in that velocity to enhance the multiples and attenuate the true reflections. The normal move out observed on the records is obscured by dip, weathering and elevation changes. With spreads shot from both ends these effects can be averaged out. Unfortunately one of the favorite field procedures is to shoot from one end of the spread only. In this case you have to do far more guessing than you like. The occasional shot, back the other way, to check the velocity assumptions, while expensive, would certainly make the final product more reliable. Here indeed is a situation where communication between interpreter, data processor and field crew is essential. Under the pressures of the short Northern season, the ever present land sales and the vast amount of data to be processed, it is a lucky man, and a brave one, who can call a halt to proceedings and take some time to experiment and to think.

I believe we should always remember the computer equation shown in figure 3. This stands for—garbage in equals garbage out. The processing devices, whether analog or digital, can add nothing of value to the data given to them, they can only subtract the undesirable, if you happen to know what it is. To be honest we have to admit that, on occasion, a playback machine will add its share of garbage to a section, either in the form of noise or faulty corrections. Maintenance of this complex equipment takes both money and *patience.*

GI=GO

FIG. 3.—Computer equation.

Analog data processing, as opposed to digital, has such limitations as phase shift, some inaccuracies in corrections and a lowering of the signal to noise ratio the more you process. In its favour is the ability to monitor with ease as you go and the intangible feel the operator can have for what he is doing. Also of some considerable value is the possibility of stopping the job as soon as something looks wrong. In some cases though, the tendency to get masses of work through as fast as possible mitigates against these advantages. With a little effort, however, it is possible to keep the lines of communication open between interpreter and machine. With the onset of digital processing this is going to be more difficult, and more expensive, and more important. Recent developments with display tubes and high speed plotters will help considerably. We are doing and will do some rather exotic and drastic things to the seismic data. It is absolutely essential that the interpreter knows what is supposed to have happened to it before he gets it. Dr. M. B. Dobrin put it very well in a recent Oil & Gas Journal when he said "Make sure that the geophysicist controls the computer and that he does not yield this control to others through lack of interest, lack of proper knowledge or lack of authority."

We are just now beginning to realize that data prep., or the preparation of the data in the proper manner to be fed to the computer, is extremely important and very time consuming. It goes without saying that it must be done right—and if it is going to be done by human beings, that is going to be difficult. Most errors will not prevent an answer of some sort coming out of the machine. It will often take a practised and a jaundiced eye to spot the wrong answers. Since the desired results will have no significance for them, most of your programmers, instrument men, and mathematicians will never be able to spot these mistakes. I suspect that the (so called) old analog equipment will be used a great deal for preliminary experimenting before the data is fed to a computer.

There is one other problem, and a totally unrelated one, that could arise shortly. The Federal Sales Tax people are contemplating the taxing of data processing as if it were manufacturing. They sound like geologists who have drilled a dry hole or two on "Seismic." This could be funny if it weren't serious. It will probably cause the first increase in data processing prices since 1958.

It has been said that data processing does not stop with the production of a cross section. An interpreter with a set of thick colored pencils can do marvelous things. This, perhaps, could be called manufacturing without much argument.