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REAL TIME ANALYSIS

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DIGITAL ANALYSIS OF GEOPHYSICAL DATA

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Geophysical prospecting is the art of searching for concealed deposits of hydrocarbons or useful minerals by physical measurements from the earth's surface. By far the greatest portion of the activity in geophysical prospecting has been in the search for oil and gas. All geophysical methods of petroleum prospecting are designed to locate geologic structures favourable for deposits of economic value. In petroleum exploration the seismic reflection method is the most widely used with gravity, seismic refraction and magnetics following in that order. Also, most of the digital processing techniques discussed in this paper apply to digitally recorded gravity and magnetic data, all the processes will be illustrated using seismic reflection data.

With the seismic reflection technique the structure of subsurface formations is mapped by making use of the times required for a seismic wave in the 5 to 100 cycles per second frequency range, generated in the earth by a near surface explosion, to return to the surface after reflection from the formations themselves. The introduction in the early 1960's of the digital recording and processing of seismic data significantly improved the usefulness of the seismic reflection method as an oil exploration tool. Typical recording systems collect 48 channels of data during 6 seconds digitized at 4 millisecond intervals every 25 meters, which represents close to three million digital reflection amplitudes per kilometer of recording. The digital computing problem involved in the processing of seismic data is therefore a sizable one which needs high-speed computers with fast input-output and large storage capacity for multichannel processing.

One of the main objectives of seismic digital processing is the improvement of the signal to noise ratio in the recorded data. The reflection seismic problem can be modelled as a communication system complete with source, channel and receiver. The source may be any one of numerous means of impulsing the earth. Only the input wavelet shape need be known to completely characterize a given source. The channel is of course, the multipath elastic layered system comprising the earth's crust and the receiver consists of the detector pickups and recording instruments. This communication system differs from more conventional systems in that the purpose here is not to transmit a message from source to receiver but to learn about the channel, i.e. the signal s(t) in the reflection problem is the sequence of impulsive reflection returns from each impedence contrast in the subsurface layering. This signal suffers considerable distortion before it is finally recorded as part of the raw seismic trace f(t). In communications terms this recorded trace may be written as :

$$f(t) = s(t) * d(t) + n(t)$$

where:

- s(t) is the desired subsurface response
- $*$ represents convolution or filtering
- d(t) is the net distortion filter which includes the effects of source wavelet, inelastic attenuation, reverberation, etc.
- n(t) is the additive noise consisting of source generated and ambiant components.

This propagation model, though simple, demonstrates a fundamental fact in seismic processing: Geophysicists must be concerned with two distinct problems that can obscure the subsurface picture - signal distortion and noise which require different signal processing approaches.

The distortion effects are amenable to single channel inverse or deconvolution type filtering provided the additive noise components are negligible. If not, one is in danger of "deconvolving the noise" which usually leads to poor results. Single channel filtering can at best give an estimate s'(t) of the signal. One way of finding a "best" filter h(t) is to minimise the average squared error between the estimate and desired signal, problem which has been rigorously developed by Wiener.

Noise suppression can be achieved through multichannel processing. This processing in its simplest form may consist of stacking, time shift and stack or in its more advanced forms, filter and stack. A multichannel processor is characterized by multiple inputs and a single output. Common multichannel systems in widespread use in seismic exploration include shot patterns or source arrays, receiver arrays, compositing and mixing. The inputs consist of signal which is about the same and noise that differs from channel to channel. Optimum multichannel filters are designed in the same way as the single channel filter by minimizing the quantity $(s'(t) - s(t))^2$ with respect to the filters $h_1(t)$, $h_2(t)$, ... $h_m(t)$. The solution for these filters requires knowledge of the correlation of signal and noise between all m channels or traces.

Another technique which is used to improve the signal to noise ratio of the seismic data is the common-depth-point (CDP) data acquisition method. Multiple coverage of the subsurface is obtained by arranging the detector spreads and the shot points so that channels representing common depth points are recorded with appreciably different horizontal distances between shotpoints and detector stations. The channels which have a common reflection point are combined or stacked after appropriate travel time corrections (called Moveout corrections) have been applied. Reflections which follow the assumed travel paths are greatly enhanced and other events are reduced.

The above signal enhancement processes combined with the ability of the computer to handle the massive amounts of data involved, have provided a much clearer picture of the subsurface structure which is displayed in the form of a record section "picture". But for all its value, this picture does not represent the ultimate potential of the digital processing of seismic data nor does it convey travel-time in a format very useful for quantitative analysis and interpretation.

Developments over the last few years have produced processing systems which can routinely extract on a continuous basis reflection arrival times, amplitude characteristics and moveout corrections for all coherent reflection events. By associating the time and the moveout correction for a given reflector it is possible to compute the average compressional wave velocity in the layers above the reflector. These data, after proper analysis, provide the basis for accurate interval velocity estimation for each individual layer and subsurface model building which will increase the oil finding capability of reflection seismology. To detect 100 feet of subsurface relief at 10 000 feet depth requires a velocity accuracy of the order of 0.5%. A similar order of accuracy permits the identification of major lithologic intervals, such as thick limestones. These accuracies are achievable today with moderate spatial averaging.

Finally, the paper will describe the use of an interactive terminal system in the analysis and integration of the data generated by the above processes into three dimensional subsurface models suitable for exploration decisions.

BRITISH ACOUSTICAL SOCIETY: Meeting on 27th November 1973 at 1, Birdcage Walk, London S.W.1.

NEIGHBOURHOOD NOISE

THE CONCEPT OF NOISE ABATEMENT ZONES

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The powers of local authorities under the present Noise Abatement Act are confined to the abatement of nuisance.

When Sir Hilary Scott's working group, at the request of the Noise Advisory Council, studied the working of the Act, they concluded that it provides no real scope for bringing about a general reduction of ambient noise levels in unacceptably noisy areas; and moreover provides no protection against creeping increase anywhere. This conclusion, the grounds for which are set out in paragraphs 134-135 of the Group's report, "Neighbourhood Noise", have not, to my knowledge, been disputed.

The Group went on to recommend that a new Noise Abatement Act should include provisions enabling local authorities, not merely to deal with individual premises which are causing a noise nuisance, but to deal with all premises which are (individually and collectively) c reating an excessively high level of noise in the neighbourhood of houses or other noise-sensitive establishments. And, more specifically, that the powers which they would need for that purpose should be made available - in addition to the existing nuisance powers - in areas of special control to be known as Noise Abatement Zones.

The Group envisaged that local authorities should be able to make an order designating a defined area as a Noise Abatement Zone and specifying target emission levels. This order would require the approval of the Secretary of State for the Environment. The local authority would then be able to take the necessary measures to bring their emissions down to the approved target levels.

Following the publication of the Scott Report the Noise Advisory Council appointed a further Working Group under the chairmanship of Mr. Rupert Taylor to look into the need for, and methods of carrying out, local noise surveys in connection with the creation and operation of NAZs. A note by this Group, which has not yet completed its work, has been circulated for this meeting.

When the Scott Report was published, the then Secretary of State initiated consultations with a wide range of interested bodies on its recommendations and it is generally known that proposals for new noise abatement legislation are being studied in the Department.

If such legislation is to make provision for Noise Abatement Zones there appear to be four questions about which we need to be clear if we are to get those provisions right and if local authorities are to be able to operate them effectively.

1. What should be the critegria for the identification of a suitable area for designation as a NAZ?
2. How are the boundaries of the Zone to be defined?
3. How is the objective which the local authority seeks to achieve in a proposed Zone to be defined?
4. How is that objective to be translated into specific requirements, to be met by particular premises?

Identification

The Scott working group did not favour any precise statutory definition of criteria for the selection of areas for designation as NAZs.

In this they were influenced by a desire to retain as much flexibility as possible.It was thought that over the years NAZ powers might be found to be well-suited to dealing with certain types of local situation which had not been specifically foreseen by the legislators. Accordingly the Group suggested that it should be sufficient to establish that a proposed Zone was an area "in which it was desired, for the well-being of those living or going about their lawful occasions there, to abate or restrain the general level of noise or vibration".

They assumed however that in the first instance, authorities would select areas where there would be an acute neighbourhood noise problem which was likely to be responsive to treatment under the new powers. These were likely in the main to be mixed areas including factories and commercial premises, a substantial proportion of dwellings, and roads (other than main through roads) carrying a substantial volume of traffic.

Rupert Taylor's Group have suggested that local authorities should have no great difficulty in identifying, from existing knowledge, areas with an acute neighbourhood noise problem; and that for this purpose compreh -ensive noise surveys (which are costly and not without problems) may well be unnecessary. The meeting will no doubt have views on that point. But in any case it does not necessarily follow that an area which has a bad noise problem is suitable for designation. To take the extreme case, if the problem is overwhelmingly one of aircraft noise, NAZ powers will clearly be of no practical use. If on the other hand there is a traffic noise problem much will depend on the circumstances. There may be considerable scope for traffic management in the interests of noise abatement using existing powers under the Planning Acts to close highways (other than trunk or principal roads) or to restrict the access of traffi on amenity grounds. But where houses face on to a heavily-trafficked principal road which must continue to be used as such, there would seem to be little purpose in including them in a NAZ.

Again if an area being considered for designation includes a predominant industrial noise source which it is not (at any rate in the present state of knowledge) technically possible to quieten significantly, to require other premises nearby to be quietened may effectively screen the plight of the local residents. Unless therefore the local planning authority is prepared to "plan out" the predominant source and to pay compensation for the loss of existing use rights, there may be nothing to be gained by designating as a NAZ.

The essential point is to recognise that a NAZ is not a panacea for all noise problems and that unless the designation powers are used discriminat -ingly they will be in danger of becoming discredited.

Boundaries

Having identified an area as suitable for designation, the next problem will be to define the boundaries of the proposed Zone. The first step would seem to be to pin-point the main noise sources in the area and the pattern of noise levels. This will involve local noise surveys which we shall be discussing later this morning.

In drawing the boundaries two considerations seem to be important:

(a) the Zone should include all the significant noise sources in the area and at least the properties mainly affected by noise from any one of them.
(As Rupert Taylor's Group has pointed out any abatement of noise at source to benefit nearby residents will automatically benefit residents further from the source.)

(b) the Zone should not include property significantly affected by noise from a source outside the Zone. If this creates a problem the external source must be brought withi the Zone.

Objective

In order to operate a NAZ it will be necessary for the local authority to define the objective they are setting out to achieve within it. The Scott Report says that the objective should be to reduce ambient noise to (or in some instances to h old it at) a given level. In other words the objective should be to meet an environmental stan dard.
At this point something needs to be said about the question of local versus national standards. In one sense it is surely fundamental to the concept of locally selected and operated NAZs that the standards to be applied within them should vary within local standards. In one Zone a reduction of ambient noise levels to 60dBA may easily be attainable; in a second to get down even to 70dBA may involve prohibitive expenditure by industrialists and others: in a third, it should be practicable to keep levels (of say 50dBA) in an already quiet area from creeping higher. But the setting of objectives will involve difficult judgements. And those on whom the financial burden of abatement will fall will not always accept the targets proposed by the local authority as reasonable. That is why the Scott Group recommended that such targets should be subject to confirmation by the Secretary of State. And as they remarked this is likely to ensure a measure of consistency of practice.
It can be assumed that the Secretary of State would have regard, for example, to any guidance on noise standards which he might have given in other contexts. And it is relevant here that detailed guidance on these matters is shortly to be issued to local planning authorities.

Requirements

The Scott Working Group were unable to devise any workable system of enforcement directly related to an environmental standard. They concluded that the desired result could best be achieved by setting target levels for noise emissions from premises and requiring the necessary measures to be taken to bring the emissions down to that level.
If this is accepted there appear to be four crucial questions which we need to consider at this meeting.

First: Should target emission levels be expressed in terms of the level experienced at the boundary of the premises or at the nearest sensitive point (for example, the window of the nearest dwelling)?

Second: In what circumstances is it likely to be possible to measure the emission level directly at the selected point? And what techniques are available for calculating the level from measurements at some other point?

Third: Should different target emission levels be set for categories of premises - factories, shops and so on? Or should the local authority have discretion to consider and set a target emission level for each separate establishment? Even if the latter arrangement was technically preferable it would I think be open to serious political objection as giving local authorities too wide a discretion; and because owners and occupiers of property in a proposed Zone would not know how it was going to affect them until after the decision to designate the Zone had been taken.

Fourth: What advice can be given to local authorities as to how they are to judge whether the achievement of a given set of target emission levels would in fact bring the ambient noise level in the Zone down to the level at which they are aiming?

I should like to close by saying how grateful we in the Department are to your Society for their initiative in organising this meeting. I hope that in the course of the papers and discussions we are to have today, much valuable light will be thrown on all the four crucial question I have just mentioned. As your Society remarked in their comments on the Neighbourhood Noise Report: it will only be possible to proceed with the Noise Abatement Zone proposal - and so reap the very real benefits for our environment which it promises - if we can be reasonably sure that the technical problems are capable of solution.