need for a radically different seismic data processing approach becomes more critical.

The ideal new approach includes (1) greatly increased capability for floating point arithmetic calculations; (2) the ability to operate on very large seismic panels directly; and (3) integral support of the enormous seismic tape and disc data transfer requirements. The 1100/80 array processing system, first installed in a production seismic processing environment in mid-1981, is a unique system with separate functional units for instruction processing, input/output and communications processing, and high performance array/vector processing, all operating directly on a very large central memory. The system, in maximum configurations, is capable of execution rates as high as 250 million floating point operations per second (200 times faster than general purpose large scale computers) but more importantly, can operate on real memory panels of seismic data as large as 8 million samples. This combined capability of very high performance and extremely large problem size offers a new tool, previously unavailable, to process effectively the new multidimensional problems of migration, statics, and velocity analysis.

Traditionally, the mathematics of large scale seismic problems have necessarily been compromised to meet restrictive computer architectures. An example is the processing of seismic panels on a trace-by-trace basis (input trace from disc, process trace, write trace to disc, input next trace, etc.) rather than a true 3-D panel representation (input a series of traces from disc, process the panel, write panel to disc or display).

Presented here are design objectives of the APS and system architecture for seismic processing, and examples of its application and benefit for problems of 3-D fast Fourier transforms, and deconvolution, contrasted with processing with traditional seismic computer systems.

The Bison GeoPro 8012 Signal Processing Seismograph: Capabilities, Design, and Operation S18.6

B. Thomas Johnson and Thor A. Olson, Bison Instruments

The GeoPro 8012 signal processing seismograph was introduced by Bison Instruments, Inc. a year ago. It consists of a general purpose microprocessor-based digital computer whose architecture is specifically directed toward seismic data acquisition and field processing. Its development results from experience with signal enhancement seismography and represents a generational advance from that technique. An important aspect of seismic data acquisition is making certain that the acquired data are valid and interpretable. Another aspect is that of providing preliminary interpretations as soon as possible. For these and other reasons, geophysicists increasingly need to examine and process data early in the exploration process.

The signal processing seismograph allows a significant degree of digital processing in the field at acquisition time. In addition, its operating speed permits waveform sampling rates of as many as 20,000 samples per second, per waveform. The current model samples 12 channels of data simultaneously, with expansion capabilities to 24 channels. Initial digitization and storage is by direct memory access; 1024 words, each 8 bits long, are allocated each waveform in the input buffer memory; 960 of these words hold data samples, one word per sample. The remaining 64 words hold other information about the waveform, such as its enhancement history, etc. Nonsaturating signal enhancement is standard in the GeoPro seismograph. This enhancement occurs in a separate memory block within the seismograph. In this memory, 1024 words, each 16 bits long, are allocated to each waveform. The enhancement is in block floating point mode, in which the enhancement program divides a potentially saturating waveform by 2, and increments of 2 exponent store each time such a division occurs. The data conversion and block floating point enhancement process for a single impact, enhancing 12 waveforms, takes less than 3 sec. The cathode ray tube display shows 12 labeled waveforms in stacked sequence, together with a tabulation of input parameters. The display also shows operator commands as they are entered, together with suitable prompts aiding the operator in use of the instrument. The display presents fresh information automatically and instantly on completion of a program sequence. On command, an onboard printer produces a hard copy of the display. The seismograph operates by computer program, entirely under keyboard command. The standard command set provides the operator with a completely functioning exploration seismograph, giving extensive control over data acquisition, enhancement, display, and printing. Input gain is controllable in increments of 6 dB. Sampling intervals are from 50 μsec to 5 msec per channel sample, in 7 increments, for 12 channels. Delayed triggering can be set in increments of 1 msec. Timed gain ranging doubles the gain repeatedly after an operator-controllable time interval. Manual triggering disarms the trigger until the operator presses an arming key. Data acquisition is fully controllable on any combination of channels. The operator can disable a channel entirely, restrict it to digitization and storage only, or can allow the full enhancement process to operate automatically. He can enhance any channel manually. The display automatically monitors whatever process the operator chooses. The operator can clear the contents of any or all channels, in any or all data storage areas. Certain data manipulation capabilities are part of the standard command set. The operator can expand or contract waveform displays horizontally or vertically. He can move the waveforms either vertically or horizontally on the display. Two cursors are available for accurate elapsed time measurement in the field. Optional applications-software libraries are under continuing development. Some of these libraries are the waveform mathematics library, the refraction library, the reflection library, and the shear wave library. A standard IEEE/488 parallel input/output port allows the seismograph to interface with many standard peripherals available commercially. An interface allows conversion to an RS-232/C serial port. A digital tape recorder is available as an optional accessory, to store waveform data for later processing and review.

Interpretation of Physical Model Tank Data With the Raster Segment Generator S18.7

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A combination of interactive raster and vector computer graphics is shown to be a useful tool in interpreting seismic data. The data displayed consist of several sets of vertical and horizontal seismic sections generated in a physical modeling tank. The display device is a 3-D vector refresh graphics system with a raster segment generator. The raster segment generator processes and displays data which can be packed with up to 16 data values per word. This increases the number of vectors that can be displayed at one time by a factor of at least 5 with a maximum of 100,000 data points. The procedures and programs used to display the data are explained. The procedure involved in making an interpretation and fitting a surface on the interpreted picks are shown. This is followed by a description of the interpretational value of being able to carry out such procedures as interactive map migration and wavelet processing. The raster segment generator allows the display of 240 traces, each with 1000 samples and at a two-level amplitude resolution. However, the vertical sections in this paper use a four-level resolution and therefore only 120 traces will be displayed per section. The number of samples and traces displayed can be varied interactively. The same capacity can be used to display horizontal sections of 3-D data that have 240 lines with 240 shotpoints on each line.

An automatic procedure has been designed to take the sections from raw data tapes and put them in display format on the disc after the interpreter specifies the display parameters. Once a set of data is in the display format, the next section can be displayed in a cycle time of 1/30th of a second. When a set of equal time sections is displayed in sequence at this rate, the result appears to be a motion picture. Alternatively, these sections can be displayed one at a time and interpreted individually.

The ability to change rapidly from one display to another, with vertical or horizontal cross-sections in display format, greatly assists the interpreter's mental picture of the subsurface. As sections are displayed, they can be interactively interpreted using a cursor controlled by a digitizing tablet. By rotating and scaling the vector interpretation, an apparent 3-D picture of the interpretation at the time can be generated. If there are problems then with certain picks, the interpretation procedure can be edited and the picks corrected. In a graphic example, a set of vertical sections across a twin-lobed faulted delta model is shown being picked. The problems associated with doing this complex interpretation are illustrated. A movie illustrating data taken across an asymmetrical gulf coast model summarizes the advantages of interactive interpretation techniques.

Time, Velocities, Depths, Maps, and Small Computers: A Seismic Interpretation Data Base System, with Examples from the Offshore California Area — S18.8

Wm. E. Good, M. D. Carter, J. C. Corwin, and C. L. Gomez, Energy Analysts, Inc.

As cost, complexity and workload in oil exploration increases, time schedules and supplies of trained manpower seem to decrease. At the same time, trends in seismic exploration seem to generate more data for analysis while we are finding more tools with which to analyze the data. A search for cost reducing and time-saving techniques has already begun. At a time, when the computer industry is producing more function for less cost, the oil industry is moving to take advantage of new developments. In particular, a seismic interpretation project, exclusive of actual geophysical interpretation, is a candidate for time-saving procedures. The interpretation project is a job of data assimilation, organization, manipulation, and presentation. New techniques in data assimilation and display have been and are being developed which should simplify and speed-up the interpretation project. The new, high-speed, low cost computers are also of great value, not only in a production mode, but in a software development mode.

Using a small computer system controlled by an interrupt-driven time-sharing operating system, an environment has been developed that provides for rapid data digitization (more than one digitizer operating at the same time), easy quality control and editing, and quick display. Both digitizers and plotters are connected directly to the computer and are under full program and operating system control. Programs have been developed to construct a seismic time interpretation data base with attendant quality control, editing and contour mapping functions. Programs have also been developed for construction of 3-D velocity fields. These two data bases can then be used for depth conversion and generation of depth maps, isopachs, average velocity maps, rms velocity seismic stacking velocities, interval velocity maps, depth-normalized interval velocity maps, and lithology maps. Provisions have been made to utilize well data to produce seismic depth maps which tie well logs. To illustrate the procedures developed, examples of projects in the offshore area of California are presented.

Thursday, October 15

Seismic 19 — Case Histories II

Internal Seismic Stratigraphic Features of Carbonate Reefs in West Texas (Permian) and Gulf Coast (Cretaceous) Examples — S19.1

John A. Ward, Teknica Inc.

Exploration for stratigraphic traps in reefal limestones is a classic area for seismic stratigraphic exploration. The diagnostic mound-like shape of reefs along with abrupt change in lithology at the margin favor detection with the seismic tool. Commonly, bedding patterns within the reef and at the interface between reef and off-reef are critical features.

Seismic traces that have been processed into Seislog® are displayed in depth with a horizontal scale of interval transit-time providing a format for geologic study. Analysis of color coded velocity contours within several known reefs illustrate the geologic significance of amplitude patterns on the conventional seismic section. This expands the concept of seismic stratigraphy from recognition of a reef to analysis of facies patterns and growth history.

At a lower Cretaceous reef marginal to the Gulf Coast geosyncline in Polk County, Texas, velocity contours outlie core, back-reef, and reef-toe facies. In this broad shelf margin, successive build-ups exhibit alternating progradation and regression. On the south flank of the Delaware basin of Permian age, Abo reef at Empire Abo field is comparable. An overall mound is present with core, fore-reef and back-reef facies illustrated with velocity contours. Internal growth of Empire Abo reef subunits is considerably more detailed than observed in the Cretaceous. Black Lake field, Natchitoches County, Louisiana, produces from lower Cretaceous age reef strata. Although definition of an organic build-up is not provided by velocity contours, the reservoir limits are depicted.

This analysis suggests that detailed seismic work in reefs can recognize subfacies, define growth history, and delineate reservoir limits. Integration of geology with seismic stratigraphy adds data for both exploration plays and development projects.

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Thin Bed Stratigraphy From Complex Trace Attributes — S19.2

J. D. Robertson and H. H. Nogami, Arco Oil and Gas*

Both model seismic data and broadband field data acquired to delineate complicated stratigraphy have been converted to displays of the instantaneous attributes of the complex seismic trace. Attribute sections enhance the interpretation of conventional sections not only by qualitatively highlighting specific properties of conventional displays, but also by quantitatively defining wavelet characteristics like dominant frequency, and stratigraphic variables like formation thickness. An example of the quantitative use of complex attributes in wavelet definition is the phenomenon that the maximum instantaneous frequency of a zero-phase Ricker wavelet is synchronous with the central peak of the wavelet and exactly equal to the frequency corresponding to the center of gravity of the wavelet's amplitude spectrum. Peak instantaneous frequency thus is a physically meaningful measure of the spectral content of a zero-phase Ricker wavelet. If the signal in a seismic section can be approximated by zero-phase Ricker wavelets, and if the geophysicist can identify occasional wavelet peaks in the sections which are uncontaminated by noise or interference, instantaneous frequencies at these samples are direct estimates of a significant and absolute spectral characteristic of the signal.

An example of the quantitative use of attribute sections in seismic stratigraphy is their application to estimation of the thickness of thin,