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# Seismic Attributes, their classification and projected utilization

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ABSTRACT

**We define the "Seismic Attributes" as all of the measured, computed or implied quantities obtained from the seismic data. Therefore, Attributes include complex trace attributes, seismic event geometrical configurations, and their spatial and pre-stack variations. We have been able to classify these seismic attributes in a manner that makes their utility more clearly identifiable. We review a classification scheme, the utilization of attributes within each class, and the combined use of attributes to improve our ability to identify reservoir characteristics. Examples are provided of attributes role in estimating the rock properties, depositional environment and interpreting seismic facies.**

## INTRODUCTION

Seismic trace attributes were first introduced in early 1970's. Balch (1971) showed estimates of amplitude and frequencies as color overlay on the seismic sections. With the availability of color display devises, Anstey, utilizing the concept of information content of radio waves, (1972,1973) produced color overlays of interval velocity, amplitude (which he called the reflection strength) and frequency. Later, Taner, Koehler, Anstey and Neidell (1973) developed the concept of the seismic trace based on the relationship of kinetic and potential energies of recorded signal. This let to the development of computation of quadrature (imaginary part) trace by the Hilbert transform. Taner et al (1979) published the details of the computation and introduced instantaneous attributes, envelope amplitude, phase, frequency and apparent polarity. Possible interpretational applications were given by Taner and Sheriff (1977). Since their inception, the complex trace attributes became one of the principal tools in qualitative interpretation. Up to that time, quantitative interpretations were based on the velocity estimates, reflection amplitude and their variation with offset. In late 1980's and 1990's possibility of predicting rock properties by complex trace attributes were recognized. This let to the intensification of attribute related papers for both SEG and EAGE meetings and publications. Relations between bed thickness and phase and frequency attribute was investigated by Robertson and Nogami (1984) and Robertson and Fisher (1988). The relationship between instantaneous attributes and the Fourier transform were studied by Bodine (1984). Taner proposed phase characteristics of thin-bedded sections, which was later reported by White (1991). Barnes (1991,1992) introduced dominant frequency, bandwidth and Q attributes and gave their method of computation. 3D seismic data and automatic event picking provided several geometrical attributes as the dip and azimuth of steepest dips. Their use was presented in a paper by Rijks and Jauffred (1991). Schuerr and Oldenburg (1988) studied the local phase spectra in computation of velocity variation with offset. Chen (1997) gave by far the most comprehensive sets of attributes. Taner et al (1994) presented the classification of attributes based on their computation and utilization.

In early interpretations, reflection shapes, dips and their terminations were the principal tools. RMS, and interval velocity estimates, bright spot technology and later introduced AVO analysis were later added to the tool box. Unfortunately, most of the time, interpretations were based on only a few of the attributes, which failed to produce accurate estimates. Complex trace attributes were also added to kit and they were used in a qualitative manner. The object of the seismic interpretation is to develop some quantitative estimates of reservoir characteristics, rock properties and lithology from the various measurements of the seismic data. By definition, "Attribute" means an inherent or characteristic quality. All of the measurements obtained or implied from the seismic data are attributes. They represent characteristic qualities inherent in the seismic data. As the experience of their use developed, it becomes evident that they could be used in combination for quantitative interpretation. Thus, the problem changed from computation of attributes to their quantitative use in reservoir characterization and lithology estimation. Taner et al (1994) gave initial classification and projected use of the complex trace attributes. In this paper, I will extend it to cover all seismic measurements and give the general classification of attributes. I will describe their actual and projected use in quantitative interpretation.

## ATTRIBUTE CLASSIFICATION:

Seismic Attributes are defined as "any or all observations extracted from seismic data which directly or indirectly help hydrocarbon explorations" . These can be in the form of velocities,amplitudes, reflection times, reflection configurations etc. Attributes also also classified based on their direct or implied information content. This applied to all class of attributes. There are attributes that have some physical meaning, such as the envelope relating to the total reflected energy. There also attributes defines some geometrical shapes or discontinuities of the reflectors, such as lateral coherency, dip or curvature of reflectors.

Attributes can be computed either on post-stack seismic traces (full or partial stacks) or prestack gathers. Further division is then done based on the attribute supplying direct measurements, or supplying implied information content. These subdivisions are:

1) Physical Attributes
2) Geometrical Attributes
3) Attribute combinations

Physical attributes are complex trace attributes corresponding to various measurements of the propagating wavefront, these include both Prestack and Poststack attributes. Geometric attributes measure the relection configuration and continuity and semblence and are primaraly used on poststack date to define reservoir structure and framework. Combination attributes combine physical and geometrical attributes to gain additional insight into specific reservoir properities and geometric configurations. Each of these three catagories will be discussed, using either pre or post stack information as approiate to demonstrate the utilization of these attributes.

**PHYSICAL ATTRIBUTES:**

Physical attributes are the seismic measurements that directly relate to wave-propagation, lithology and other physical parameters. We divide the Physical attributes into two sub-classes, Instantaneous attributes and the Wavelet attributes. These attributes have utilization with both pre and post stack data.

**INSTANTANEOUS ATTRIBUTES**

Instantaneous attributes are computed sample by sample computed from the complex (analytic) seismic trace and indicate continuous change of attributes along the time and space axis. They vary sample by samplle, trace by trace. They are very usefull in studying this bedded features, and stratigraphic boundries. Also can be a hydrocarbon indicator, as well as localized reservoir hetrogenities such as fracturing, and localized faulting.

**WAVELET ATTRIBUTES**

The Wavelet attributes represent characteristics of wavelet and their amplitude spectrum. We compute seismic trace envelope and pick all envelope minima. Wavelet attributes are statistical quantities representing some characteristics of the Fourier transform of the local wavlets, as shown by Bodine (1984). These attributes indicate spatial variation of the wavelets, thus relate to the response of the composite group of individual interfaces below the seismic resolution. These are used to determine fluid boundaries, lithological changes, and lateral stratigraphical variations in the reservoir.

GEOMETRICAL ATTRIBUTES:

Geometrical attributes were initially thought to help the stratigraphic interpretation. However, further experience have shown that, the geometrical attributes defining the event characteristics and their spatial relations, quantifies features that directly help in the recognition of depositional patterns. Some of the ways geometric attributes are utilized include, Event picking, Indicator of parallel bedding zones, Indicator of convergent or divergent bedding zone, indicator of event terminations and unconformity, and bed thickness indicators.

**COMBINATION OF ATTRIBUTES:**

Combining Physical and Geometrical attributes can provide additional insight into reservoir morphology, heterogeneity and identification of specific lithology types. These include chaotic reflection zones, Combined geometrical and physical attributes for sand/shale zone detection, Carbonate layer detection, and validity of stack section estimation.

SPECIAL APPLICATIONS OF PRE-STACK ATTRIBUTES

Pre-stack attributes are used for studying individual seismic trace behaviour with repect to offset and azimuth versus time or depth. These include velocity estimates, AVO effects on ampitude, phase, frequency and other attributes. Post-stack attributes are the attributes computed from the statiscal average of traces going into stack ( NMO applied or migrated ). Therefore their quality will depend on the accuracy of the velocity functions. Pre-stack attributes give additional insight into the physical properities of the reservoir, including under specific conditions, some direct prediction of hydrocarbons.

Pre-stack attributes include both Instantaneous and wavelet attributes including: RMS velocities of Reflectors, Energy Absorption and Dispersion, AVO attributes, group and phase velocities, dispersion measurements.

CONCLUSIONS

Starting with the basic defination of seismic attributes, we define the attributes into three classes, physical, geometrical

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and combination attributes, each have specific uses in estimating the rock properties, depositional environment and interpreting seismic facies.

- Physical attributes include both Instaneous and wavelet attributes both of which have uses in estimating lithology and other physical properities.
- Geometric attributes give estimates of the reservoir structure and hetrogenity as well as indications of specific lithology types which represent unique geometric configurations.
- Combination of attributes, can provide unique insights into reservoir characterization and allow detialed estimation of reservoir morphology, hetrogenity and lithological makeup.
- Prestack attributes give additional insight into the physical properities of the reservoir, including better estimation of lithology properities and fluid content in the reservoir.

Examples of the utilization of attributes in several different geological enviorments are presented.

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