the petroleum industry. However, nonlinear sweeps can seriously degrade seismic data when the amplitude and frequency controls are used incorrectly.

The amplitude controls are used to overcome decoupling, ground roll, and vibrator/ground resonance problems. By suppressing the vibrator drive at the lower frequencies, the typical decoupling effect can be eliminated and the effect of the ground roll minimized. This permits the use of shorter geophone arrays that are more suitable for high resolution recording. In addition, the use of a lower amplitude sweep at the low end of the frequency range helps suppress vibrator/ground resonance. This reduces the large amplitude of the resonance frequency and allows the recording of the weaker high frequency signal.

The ability to control the rate of frequency change during the sweep allows the user to recover an improved signal-to-noise ratio at the higher frequencies. In general, the sweep time is reduced in the lower frequencies and increased in the higher frequencies. The high percentage of sweep time at the high end of the frequency range results in an improved signal-to-noise ratio in the higher frequencies. However, the improper choice of the start and end sweep frequencies can result in recovered data that is actually poorer in signal-to-noise ratio than an equivalent linear sweep.

The nonlinear method is a powerful, but sensitive tool that can be beneficial when used properly. The tool allows the user to recover excellent data in "good" data country and fair data in "poor" data country. We use Pelton's Advance I, Model 5 vibrator electronics together with the FT-1/DFS-V seismic exploration system and test extensively in the field. Areas where we have recovered excellent data include the Williston, Powder River, Big Horn, and Wind River basins.

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Early Dolomitization: its Significance in Creating Subtle Diagenetic Hydrocarbon Traps in Williston Basin

Most of the Paleozoic section of Williston basin is a thick accumulation of numerous carbonate to evaporite, shallowing-upward, cyclic sequences. These sediments were deposited in broad epeiric seas, and the deposition of the evaporite facies marked the final stage of each cycle. Many of the sequences display a pervasive replacement dolomite in the uppermost portion of the carbonate units. This secondary dolomitization is, at least in part, an early diagenetic event, synchronous with evaporite deposition.

The inception of evaporite precipitation resulted in the seepage of a dense, magnesium-rich brine into the underlying sediment. The heavy brine moved down the gentle regional dip, displacing the more normal marine interstitial pore fluid and dolomitized the primary calcitic sediments en route. The supply of magnesium-ions decreased away from the source, and correspondingly, the degree of dolomitization decreased and larger crystals formed because of slower nucleation at fewer sites.

The seepage refluxion of dolomitizing brines gave rise to the frequently observed textural variation of cryptocrystalline, impervious dolomite grading into a finely sucrosic, permeable dolomite downdip. This diagenetic facies change provides the critical updip barrier for potential hydrocarbon reservoirs. The lateral pool boundaries are controlled by either structural relief or a similar diagenetic facies change. The reservoirs are capped by the tight evaporites.

Hydrocarbon production is attained from diagenetic traps in the Mississippian Oungre Zone and the Ordovician Red River "C" Zone. Reservoir creation and the pooling mechanism are the result of dolomitization by seepage refluxion of dense, magnesium-rich brines beneath restricted, hypersaline lagoons.

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Reconnaissance and Economic Geology of Copper Mountain Metamorphic Complex, Owl Creek Mountains, Wyoming

The Copper Mountain metamorphic complex lies within a westerly trending belt of Precambrian exposures known as the Owl Creek Mountains uplift. This mountain range lies along the southern edge of the Big Horn basin, separating that basin from the Wind River basin to the south. Rocks of the metamorphic complex are exposed at Copper Mountain, at Wind River Canyon, and apparently continue several miles to the west on the Wind River Indian Reservation.

The metamorphic complex at Copper Mountain is part of a larger complex known as the Owl Creek Mountains greenstone belt. Until more detailed mapping and petrographic studies can be completed, the Copper Mountain area is best referred to as a complex, even though it has some characteristics of a greenstone belt.

The metamorphic complex is amphibolite-grade metamorphosed supracrustal rocks that have been migmatized along the north and south margins of the complex by the intrusion of leucogranitic stocks and batholiths. The regional trend of the metamorphic complex is N50° to 80°E, and regional foliation dips steeply to the south. The dominant structure along the southeastern margin of the belt is a synform. The supracrustal rocks are quartz, hornblende, plagioclase gneisses and schists, quartzites, para-amphibolites, pelitic schists, cordierite schists, iron formation, quartz-mica schists and gneisses, and intercalated orthoamphibolites.

At least three episodes of Precambrian deformation have affected the supracrustals, and two have disturbed the granites. Prior to the intrusion of granite, the metamorphic complex experienced coaxial folding of the metasediments. Following the initial folding of the supracrustals, the Copper Mountain belt was intruded by leucogranite about 2.7 b.y. ago. This intrusive event is believed to be responsible for prograde metamorphism, as well as a second phase of deformation. Portions of the supracrustal belt were mineralized during the waning stages of the intrusive event. Some tungsten-bearing veins and calc-silicates were produced. Auriferous and cupriferous fracture-fill veins were formed, followed by emplacement of simple pegmatites.

A final Precambrian deformation event was preceded by a weak thermal event expressed by retrogressive metamorphism and restricted metasomatic alteration. During this event, a second phase of pegmatitization was accompanied by hydrothermal solutions.

During the Laramide orogeny, Copper Mountain was again modified by deformation. Laramide deformation produced complex gravity faults and keystone grabens. Uranium deposits were formed following major Laramide deformation. The genesis of these deposits is attributable to either the leaching of granites or the leaching of overlying tuffaceous sediments during the Tertiary.

Production of metals and industrial minerals has been limited, although some gold, copper, silver, tungsten, beryl, feldspar, and lithium ore have been shipped from Copper Mountain. A large amount of uranium was produced from the Copper Mountain district in the 1950s.

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Conodonts of Bakken Formation (Devonian and Mississippian), Williston Basin, North Dakota

The Bakken Formation is a thin (maximum 145 ft, 45 m), clastic unit in the subsurface of Williston basin in the United States and Canada. The formation consists of three informal members which display an onlapping relationship. A lower, radioactive, pyritiferous, noncalcareous black shale is overlain by a light to dark gray, dolomitic siltstone to calcareous sandstone and an upper black shale similar in lithology to the lower shale. The finely laminated, organic rich, black shales of the Bakken Formation were deposited in an anoxic, marine environment that was apparently offshore, sediment-starved, and below wave base. The middle member contains bedding features and fossil evidence indicative of a slightly dysaerobic, current-influenced, marine environment. The upper and lower black shales are considered important source rocks for hydrocarbons in the Williston basin.

The Bakken is similar in lithologic character and stratigraphic position to other "black shale" units deposited on the North American craton during the Late Devonian and Early Mississippian. The Bakken was initially considered entirely Mississippian in age. Paleontologic study of regional physical equivalents and analysis of the macrofauna in Saskatchewan has suggested that the Bakken is actually both Devonian and Mississippian.

Conodonts were obtained from cores of the Bakken in an effort to determine the age of the formation in North Dakota and to assess the oil generation potential. Nearly 700 conodonts have been recovered, but are unevenly distributed within the Bakken Formation. A majority was obtained from thin (approximately 0.5 cm), fossil-rich beds within the upper shale. Conodonts from the top of the upper shale reveal a Mississippian (Kinderhookian) age and are here assigned to the Lower *Siphono-*