of the "Wolfcamp" in the basin is the top of the "3rd Bone Spring Sand" (or Dean) —a regional subsurface marker within the western Delaware basin. On the adjacent platform the "Wolfcamp" is bounded on the top by the Drinkard Sandy Member of the Yeso Formation—a regional subsurface marker on the Northwestern shelf. The base of the "Wolfcamp" commonly is defined by a regional unconformity which overlies rocks ranging in age from Late Pennsylvanian to Precambrian.

"Wolfcamp" strata in the western Delaware basin locally exceed 6000 feet in thickness and are among the least well-known sequences in the basin. These strata are generally dark colored and the carbonates are generally lime packstones, wackestones, and mudstones. The "basinal Wolfcamp" can be subdivided into (1) a lower detrital unit which is quite variable in thickness and lithology, (2) a middle sequence of lime-shale-lime which is somewhat more uniform in thickness and lithology, and (3) the "3rd Bone Spring Sand" which is quite uniform in thickness and lithology. All of these units probably were deposited in a basinal (relatively deep water) environment. Deposits of the lower detrital unit range from conglomerate to feldspathic sandstone to shale and tended to level out the irregular basin floor topography created by Late Pennsylvanian-Early Permian tectonism. Taken as a whole, the "basinal Wolfcamp" records a transition from a period of active tectonism to one of relative stability.

In contrast, "Wolfcamp" strata on the Northwestern shelf are generally light colored, the carbonates are commonly dolostone, and most of the rocks have grain-supported textures. The "shelf Wolfcamp" strata were probably deposited in environments ranging from nonmarine to shallow water marine. The "shelf Wolfcamp" can be subdivided into (1) a lower clastic unit which locally exceeds 2,000 feet in thickness north of the Huapache fault zone, (2) the Abo-Hueco Formations, a thick carbonate tongue grading northwestward into Abo red beds, (3) the lower carbonate-evaporite member of the Yeso Formation, and (4) the Drinkard Sandy Member of the Yeso Formation.

Correlation between "basinal Wolfcamp" and "shelf Wolfcamp" sequences is difficult. Details of the stratigraphic relationships in these sequences are complex and as yet poorly understood. The lower clastic unit of the "shelf Wolfcamp" is similar in age and closely resembles, in lithologic variation (red beds to clean carbonates) and tectonic setting, the Laborcita Formation in the northern Sacramento Mountains. The Abo-Hueco carbonate tongue represents a major marine transgressive-regressive cycle. The lower member of the Yeso represents a similar cycle which terminated in the deposition of the Drinkard.. The Drinkard Sandy Member is believed to represent the remnant of great quantities of very fine sand and silt which were transported across the Northwestern shelf to the Delaware basin where it accumulated as the 3rd Bone Spring Sand.

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March 21, 1966

JOHN P. DOWDS

Consultant, Oklahoma City

"Mathematically Derived Prospects"

The gas and oil search is considered a mathematical problem. The branch of mathematics best suited to the hydrocarbons hunt deals with probability theory and statical analysis. As holes are drilled at random and information is collected from them, it is found that some data may occur within a certain range of probabilities, that is, the process occurs stochastically. By turning to certain probability formulas as found in statistical physics and information theory, the data can be used to configure density patterns or contour maps to obtain ideas as to what percentages of success a series of holes will be expected to have. In some areas, less sophisticated methods can be used effectively in evolving patterns compiled from fixed and random data.

Accurate definition of a discovery or development well can be difficult. When a well is predicted to find hydrocarbons several miles from production it is normally considered as a discovery. But in an area that is geologically and engineering-wise in varying stages of statistical equilibrium, the well might be considered as a verification of prior knowledge and actually a development well. The obvious utility of this information is for an operator to acquire diversified lease blocks before acreage prices soar, and then to optimize a drilling program to verify or gain the most information.

In any statistical argument it is not easy for a single point to be proven. But if evidence in percentages shows an overwhelming regularity when dealing from original

positions of uncertainty, then many successes should settle the argument as a practical matter.

The author quotes from previous reports, some of them unpublished, to emphasize the "before and after" (case history) approach.

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April 4, 1966

WILLIAM W. MALLORY
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"Pennsylvanian System in Wyoming"

Despite the fact that the stratigraphy of the Pennsylvanian System in Wyoming is essentially simple, the literature contains abundant differences of opinion which are puzzling to the geologist seeking an integrated, coherent concept. By returning to Darton's original definitions of the Tensleep and Amsden Formations and applying his criteria to surface and subsurface sections in central and western Wyoming, it is possible to defend, by sections and by thickness and facies maps of each significant unit, the following statements. The Amsden Formation is a tripartite lithologic unit. Its basal member, the Darwin Sandstone, has irregular limits and thickness but is widespread in the Wind River and Bighorn basins where it lies on a karst topographic surface developed on the Madison Limestone. A middle red shale has nearly constant thickness and lithology. An upper carbonate member is widespread in northwestern Wyoming but is lacking on the Pathfinder uplift (the most northerly of the Ancestral Rocky Mountain uplifts) and grades southward into the Fountain and Casper Formations. The Tensleep Sandstone everywhere overlies the Amsden.

Sources for the sand in the Darwin and Tensleep, either from the northwest as suggested by some, or from the Ancestral Rocky Mountains as alternately suggested, are discarded in favor of a widespread older Paleozoic sandstone in the Hudson Bay region which had been exposed to erosion in Pennsylvanian time.

The Darwin Sandstone, an ideal reservoir rock, is composed of exceptionally pure, well-sorted quartz sandstone. Production is currently obtained from the Tensleep in numerous anticlinal reservoirs; but may also yield from other types of traps. Facies-change belts, as in the gradation of the Tensleep into the Minnelusa, and that between the Casper, Fountain, and Morgan Formations, may have unsuspected possibilities.

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April 21, 1966

JOHN F. HARRIS, Consultant, Tulsa

"Dolomites: Their Stratigraphic and Structural Significance"

Previous work on fractures has shown that a relationship exists between their development and concentration and the local and regional structure upon which they occur. These areas of concentration can be illustrated through preparation of an isofracture map which shows maximum concentration to be in areas of highest rate of dip and/or strike change.

Field and subsurface work shows that tectonic dolomites have the same fabric relationship to local and regional structure and are related to fracture concentration areas on structure. These tectonic (secondary) dolomites constitute important oil reservoirs in the subsurface and include the Deep River field (26 million barrels) and the Scipio-Albion field (100 million barrels) of Michigan. Often, the crest of a structure may be barren (tight) while a major tectonic dolomite reservoir may be present on the shoulder or flanks of the structure.

Petrographic criteria are available to distinguish tectonic (secondary) dolomites from depositional dolomites. Once porosity due to the former tectonic cause is differentiated from the depositional fabric, considerable progress can be made in constructing the depositional fabric of an area in the search for stratigraphic traps. Depositional dolomites appear to be related to the crystal instability of aragonite and may in part be of facies significance (quiet water lagoonal facies). The increment concept of primary carbonate deposition illustrates lateral as well as vertical facies relationships. Oil traps related to these primary depositional changes include the Putnam fifeld of Oklahoma, the Hermosa (Aneth, etc.) production of the Paradox basin in Utah, the Mississippian production in North Dakota (Rival pool), Canada (Midale pool), and the Cottonwood (Permian) field of Wyoming.

Many other oil reservoirs related to both tectonic and depositional dolomitization and carbonate facies can be cited. Recognition of these two entirely different origins and occurrences of dolomite and related porosity is necessary for exploration purposes.