bayment southwest of the Defiance area during latest Givetian or earliest Frasnian time. In early Frasnian time, the Aneth Formation and unit 1 of the Jerome Member, Martin Formation, were deposited as fine-grained intertidal carbonates in northeastern and central Arizona, while the lower Temple Butte Formation carbonates formed in a more open circulation subtidal marine environment in northwestern Arizona. Between these two areas the Marble Canyon-eastern Grand Canyon area was a positive feature (here called the Grand Canyon shelf) that remained very near sea level and received little or no sediment.

By late Frasnian time depositional environments in northeastern Arizona had changed from intertidal-supratidal conditions to those of a shallow subtidal sea with restricted circulation in the east (the Elbert Formation pelleted carbonate rocks) and more open-marine circulation toward the south and west (the fossiliferous carbonate rocks of the upper Jerome Member and western Temple Butte Formation). The Grand Canyon shelf received carbonate sediments in intertidal channels and on a shallow subtidal platform to form the thin Temple Butte Formation.

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Pennsylvanian and Early Permian Paleogeography, Southern Colorado Plateau and Vicinity

Pennsylvanian and Lower Permian sedimentary rocks of the southern Colorado Plateau have been the subject of controversy concerning their correlation and origin. Paralic sediments of the Supai group (Morrowan, Atokan, Virgilian, and Wolfcampian) were deposited in the Grand Canyon embayment. A persistent southwest-trending unstable area, herein named the Sedona arch, confined all Supai sediments, except Virgilian, to the Grand Canyon and western Mogollon Rim regions; older strata are truncated by the sub-Virgilian unconformity.

Marine rocks of the Naco Group (Desmoinesian, Missourian, and Virgilian) were deposited on the Mogollon Shelf. Only Virgilian rocks cross the Sedona arch. Thus the bulk of Supai and Naco sedimentary rocks are not as closely related as most previous workers had thought.

The northwest-trending Kaibab arch provided the barrier between the Hermosa Group of the Paradox basin and the Supai and Naco to the south; therefore, most of the Supai, Naco, and Hermosa groups were deposited in distinctly separate basins.

The Wolfcampian Esplanade and Cedar Mesa Sandstone Members and Halgaito formation form a distinct eastward-thinning wedge of sedimentary rocks west of the Sedona arch. These high-energy marine shoreline and supratidal sedimentary rocks grade westward into thick marine carbonate rocks of the Cordilleran geosyncline. A widespread red-bed sequence comprising continental and possibly tidal shoreline deposits of the Hermit and Organ Rock formations was deposited across the entire study area.

The youngest sequence studied consists of sandstone, red beds, evaporites, and carbonate rocks of the Schnebly Hill formation and DeChelly Sandstone (Leonardian). These units are centered around the Holbrook basin and represent a complex of shallow-marine, high- and low-energy shoreline, eolian, and sabkah depositional environments. Both formations grade upward into the overlying Coconino Sandstone and related rocks.

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Applications of Probable Range Concept to Biostratigraphy

The probable range is the most frequently observed range of a taxon. Probable ranges are derived from a snythesis of local ranges characterized among a group of geologic sections. The local ranges provide the empirical biostratigraphic data from which the time and space distribution of a fossil is integrated. This distribution is approximated by the probable range.

The probable range concept is currently being applied to the biostratigraphy of many regions and is demonstrated using a North Atlantic Ocean data set of 228 species of Cenozoic and Mesozoic calcareous nannofossils occurring at 55 sites drilled by the Deep Sea Drilling Project. A major result of the application is a standardized range chart for the data set. Comparison of the range chart with published range data shows a good correlation. The rigorous application of the probable range concept sets no theoretical limits on the maximum size of a data set. This offers the potential of very high resolution and equally reliable alternatives to standard biostratigraphic zonations. The global application of the probable range concept will have a fundamental impact on the earth sciences by providing a standard biostratigraphic reference system invaluable to the interpretation of the time and paleoenvironmental relations among geologic sections.

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Distribution and Alteration of Ogallala Volcanic-Ash Deposits and Their Possible Relation to Uranium Mineralization in Western Oklahoma

Diagenesis of the Ogallala (upper Miocene-Pliocene?) and Pearlette (Pleistocene?) rhyolitic volcanic ash in western Oklahoma was studied. The Ogallala ash ranges from relatively fresh to highly altered. Chemical changes during its devitrification are characterized by a loss of silicon, sodium, potassium, and uranium, and addition of magnesium to the ash. The thorium to uranium ratios range from 4:1 to 10:1 for relatively unaltered ash to 16:1 to 64:1 for the highly altered ash. The average loss of uranium due to devitrification is greater than 3 ppm. Migration of the released uranium in the alteration system was made possible by carbonate complexing agents.

Study of the Ogallala Formation in the high plains and equivalent formations in the Gulf coastal plain indicates that these strata originally were widespread over most of Oklahoma but that the sediments were removed