tions contain at least seventeen deep channels (10 to 50 feet), which appear to have been both cut and filled by turbidity currents. The association of deep channels and proximal turbidite sedimentation suggests that the environment of deposition of the Shale Grit was a submarine fan, similar in most respects to the fans at the foot of the Monterey and La Jolla canyons. The Grindslow Shales were probably deposited on the slope above the fan.

The sequence from the Mam Tor Sandstones (distal turbidites) via the lower Shale Grit (distal, with subordinate proximal turbidites) into the upper Shale Grit (proximal, with subordinate distal turbidites) suggests advance of a submarine fan into the central Pennine Basin. The advance continued as the Grindslow Shales slope environment covered the fan, and was itself covered by the nearshore or coastal plain Kinderscout Grit.

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Late Paleozoic Deltas in the Central and Eastern United States

Environmental mapping in Pennsylvanian and Mississippian rocks from Oklahoma to Pennsylvania has shown that most lenticular masses of sandstone and shale are parts of deltaic complexes. In Late Mississippian and Pennsylvanian rocks, deltaic expansion commonly follows brief marine transgressions. Widespread marine limestones may terminate against broad arcs of prodeltas composed of evenly laminated gray shales with ironstone nodules. The prodelta deposits become more sandy upward and are succeeded by conformable sheet sands or unconformable lenticular sandstones. Thicknesses of the combined delta and prodelta deposits in eastern and central United States are as much as 150 feet, composed entirely of shale, or sandstone or both.

Source areas for delta sands are north, east, and southeast of the Appalachian basin; northeast and north of the Illinois basin and northern Mid-continent; and south, southeast, and southwest of Oklahoma. The Ozark uplift, Nemaha ridge, and central Kansas uplift were unimportant sources; the Canadian shield, northern Appalachians, Transcontinental arch, and Ouachita and Arbuckle uplifts were principal sources. Deltaic growth from different directions was not contemporary.

Detailed mapping of minor features of these deltas, now in progress, shows intricate patterns of sand and shale and indicates that surface configuration of a delta is an important determinant of distribution and thickness of Pennsylvanian coals. Four deltas have been studied in the Lower Mississippian (Pepper and Dewitt), twelve in the Upper Mississippian (Swann and Potter), and twenty in the Pennsylvanian. Examples of entire deltas and details of portions of deltas are illustrated.

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The Stratigraphy and Sedimentary Petrology of Miocene Turbidites in the San Joaquin Valley

A thick Miocene marine basinal succession, dominantly sandstone, underlies the southern portion of California's San Joaquin Valley. Deposited in paleontologically defined depths of as much as 5,000 to 6,000 feet, the sands are pebbly and gritty to fine grained, largely angular, poorly sorted, often silty and micaceous, quartzose to arkosic and are interbedded with dark carbonaceous shales. Graded bedding is common and in conjunction with depth estimates is taken to imply turbidity current origin for most of the sands.

Early Miocene turbidites spread far southwestward from the Sierra Nevada provenance, but by late Miocene, anticlinal barriers, rising from the sea floor, restricted the turbidites, including the highly productive Stevens sands, to the northeastern side of the basin. These late Miocene sands at first entered from discrete troughs or canyons but later from more widely dispersed sources as shelf sands encroached. Deep basinal transport seems to have been axially northwestward. Locally, thick Stevens synclinal channel sands spread eastward off the rising Temblor Range. Sudden cessation of basinal sand deposition was followed by deposition of chert, shale, and Pliocene neritic sediments.

Detailed subsurface correlations show that Stevens sand bodies include sinuous channel fills bounded by major anticlines, sands flanking and covering lower structures, and lobate and branching apron sands in simple homoclinal areas. Compaction structures are shown to control some accumulations and offer clues for continuing exploration.

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Chemical Composition of Siderite Nodules in the Environmental Classification of Shales

In the search for geochemical indicators for the environmental classification of non-fossiliferous, clastic sedimentary rocks, the chemical composition of 45 syngenetic "siderite nodules" from shales of Pennsylvanian age was investigated. Nodules were assigned to three categories on the basis of closely associated fossils: (1) FW—freshwater (*Estheria*, *Leaia*, *Anthraconauta*, *Carbonicula*), (2) B—brackish, restricted marine or near-shore marine (*Lingula*, *Orbiculoidea*, *Dunbarella*, *Aviculopecten*), and (3) M—marine (*Chonetes*, *Mesolobus*, etc.). Of 11 elements determined, Si, Al, Mg, Ca, Ba, and V are useful as environmental discriminators. Means (and standard deviations) of these elements by category are as follows:

	% SiO_2	% Al_2O_3	% MgO	% CaO	% Ba	% V
FW	30.75 (12.8)	13.42 (7.25)	2.22 (.674)	2.55 (2.17)	.0360 (.0118)	.0094 (.0039)
B	13.67 (7.44)	5.77 (3.95)	2.47 (1.32)	2.97 (.824)	.0180 (.0110)	.0110 (.0042)
M	11.56 (3.25)	4.84 (1.12)	3.58 (1.02)	5.81 (1.66)	.0140 (.0033)	.0140 (.0043)

A three-group, six-variable discriminant permits complete separation of individual FW and M samples, but is less successful in distinguishing the brackish and restricted marine shales as a separate category. Siderites forming during sedimentation may prove especially useful for environmental discrimination where variations in the detrital to authigenic clay mineral ratio diminish the value of trace element indicators in the argillaceous fraction of the rock.

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O^{18}—O^{16} Ratios of Evaporitic Dolomite From the