energy-short nation, western coal can be the "Clean Black Ace in the Hole."

## SEPM Abstracts of Papers

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### PETROLOGY OF MORRISON FORMATION, DINOSAUR QUARRY, UTAH

No abstract available.

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### MANNVILLE (LOWER CRETACEOUS) BASIN OF SOUTHWESTERN SASKATCHEWAN

The Mannville Group is represented by the Success (new name), Cantuar, and Pense Formations. The Success Formation, Neocomian in age and lying on a low relief unconformity across the Swift Current region, is dominated by sandstones of quartz and kaolinite with accessory chert and spherosiderite. A bipartite lacustrine to fluviatile succession, the Success Formation is correlated with the upper Morrison and the Lakota sandstone of central Montana. Its provenance is deduced to have been the Precambrian shield. The tripartite Cantuar Formation lies on a high-relief unconformity that dissects the Success and all Jurassic strata in the area. At the base of the pre-Cantuar relief is the McCloud Member (new name). It is composed largely of autochthonous sandstones overlain by an estuarine to marine shale that reaches southward from east-central Alberta to the international border in Saskatchewan as ria-like fingers of the marine Ellerslie Formation. The member is Aptian in age, is correlated with the Third Cat Creek and Cut Bank sandstones of the Kootenai of Montana, and with the Success Formation, is correlated with the lower Mannville of Alberta. The Albian Dimmock Creek and Atlas Members (new name), by virtue of their chlorite and biotite content, constitute the green feldspathic facies of the Mannville and Kootenai that are distributed across southern Saskatchewan from the Rocky Mountains of southwestern Alberta. Fluviatile to deltaic-marine, these deposits were laid down on sedimentation surfaces that progressively encroached upon and largely buried the pre-Mannville topography. The Pense Formation is entirely marine and is composed of four units represented in general by (1) basal black shales, (2) dark gray and black bioturbated sandy mudstones, and (3) well-sorted, bedded and crossbedded, fine to medium calcareous sandstones. The last are thought to have formed under wave conditions as a culmination of sediment buildup on the crown of the submerged Swift Current platform prior to renewed foundering of the platform. The Pense sandstones grade into the silts and black shales at the base of the Colorado Group in central Montana.

Locally, sedimentation was controlled by episodic uplift of the Swift Current platform from the Middle Jurassic Shaunavon basin. This uplift began during the Late Jurassic and reached a climax (500-700 ft) during the earliest Cantuar, but continued into post-Cantuar-pre-Pense times. Now, the platform forms the broad structural keel of southern Saskatchewan, having down-tilted about 1,600 ft from its early Cantuar elevations. Its mass is furrowed by valley sinks and punctuated with knobs created by the episodic dissolution of salt from the Middle Devonian Prairie Evaporite.

The oil reservoirs occupy the northwestern updip edge of the Roseray and Success Formations and lie in mesas enveloped by Cantuar argillaceous valley fill. The oil reservoirs are also under the influence of a massive high-pressure potentiometric cell and its subsidiaries on the west, that are pressurized by the upwelling of waters from the Paleozoic limestones through a regional linear zone of structural weakness. The easterly to southeasterly downdip flow through the Cantuar semipermeable barriers acts to enlarge the trapping capacity of the reservoirs. Oil prospects lie in unlocated Roseray and Success mesas, and structural highs in general. Other prospects are associated with permeable sandstones of the upper Mannville beds, as well as channel sandstones of the McCloud Member. Gas prospects in addition are found in the updip edge of the Pense Formation.

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### PRIMARY AND SECONDARY SEDIMENTARY STRUCTURES IN FINE-GRAINED LACUSTRINE ROCKS OF GREEN RIVER FORMATION (EOCENE), PICEANCE CREEK BASIN, COLORADO

A study of 285 polished slabs (59.0% oil shale, 23.0% carbonate, and 18.0% fine-grained clastic rock) collected from four measured sections along the southern and eastern edge of the Piceance basin reveals important sedimentologic information on the distribution of primary and secondary sedimentary structures. The slabs were studied under low-power binocular magnification, and individual stratification characteristics were noted. A total of 528 primary structures and 334 secondary structures were observed in the slabs.

Eleven descriptive classes of primary structures are important: (1) even parallel stratification; (2) discontinuous even parallel stratification; (3) wavy parallel and nonparallel stratification; (4) discontinuous wavy parallel and nonparallel stratification; (5) discontinuous curved parallel stratification; (6) curved nonparallel stratification; (7) structureless; (8) mottled; (9) brecciated; (10) algal stratification; and (11) graded stratification. Of these classes, the oil shale is dominated by classes 1, 2, 3, and 4, and the carbonate and fine-grained clastic rocks by classes 6, 7, 8, and 10. Classes 5 and 9 are rarely represented.

Apparently there is a correlation between the organic content and the stratification type of the oil shale. As oil shale increases in organic content, classes 2 and 4 become more abundant and classes 1 and 3 are less so. In the oil shale of the Parachute Creek Member of the two easternmost measured sections, class 1 decreases, whereas classes 2 and 4 increase upward through the sections. The older classes remain approximately the same. These vertical changes correlate with indications of desiccation in the depositional environment in the upper parts of the Parachute Creek Member.

Six classes of secondary sedimentary structures are common: (1) loop structure; (2) fault displacement; (3) crystal-growth displacement; (4) bioturbation; (5) contortion; and (6) total disruption. Most of these classes are restricted to oil shale, and loop, fault and crystal-growth types are most abundant. The frequency

of occurrence of the secondary structures, like the primary structures, varies with lithology. Crystal-growth disruption (sulfides and carbonate clots) in the oil shale increases with increasing organic content. In a vertical sequence of oil shale in the Parachute Creek Member, crystal-growth disruption of laminae increases upward through the section, and loop and fault structures decrease. Contortion of laminae is almost exclusive to the oil shale, and bioturbation is restricted to claystone and very limy claystone.

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DIPMETER INTERPRETATION OF STRUCTURAL AND STRATIGRAPHIC FEATURES IN ROCKY MOUNTAINS

No abstract available.

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ORIGIN OF Ca, Fe, AND Mg CARBONATES IN OIL SHALES OF EOCENE GREEN RIVER FORMATION IN COLORADO, WYOMING, AND UTAH

Calcium and magnesium carbonates are perhaps the most widespread minerals in the oil-shale sequence of the Green River Formation. Crystallography and chemical composition of the principal carbonate minerals in the oil shale indicate a wide range in mineral composition that includes calcite, Mg-calcite, dolomite which is iron-free and has normal 1:1 Ca:Mg, dolomite with low iron and excess Ca, ankerites with excess Ca, siderite, magnesiosiderite with low Ca, and aragonite.

Recognition of the ubiquitous presence of Mg-calcite in these rocks seems important in reconstructing a plausible depositional model for the sedimentary environment and origin of the kerogen-rich shales. Recent studies show the ability of algae and many invertebrates to precipitate high Mg-calcite in aqueous saline environments. Biogenic precipitation of calcite in the hypersaline waters of the Green River lake may account for the higher Mg-content of laminae adjacent to and within high-kerogen zones than in low-kerogen zones.

Subsequent to the inferred biologic precipitation or accumulation of high Mg-calcite in the upper levels of the lake, the Mg-calcite sank to a lower zone of extreme salinity after death of the organism. Postdepositional processes in the lower zone of accumulation may have converted high Mg-calcite to low Mg-calcite and dolomite, as suggested by the presence of this mineral assemblage in many of the samples studied. Development of ankerite, siderite, and magnesiosiderite is believed to be authigenic or diagenetic. Metastable carbonate minerals such as Mg-calcite plus dolomite with excess Ca, or Mg-calcite plus ankerite with excess Ca have been identified in a single polymineralic grain. This finding makes untenable an interpretation of the oil-shale mineral assemblage based on conventional equilibrium conditions for the system $CaCO_3$-$MgCO_3$-$MgCO_3$-$FeCO_3$ at 25°C.

We find no compelling mineralogic or chemical evidence that indicates precipitation of calcite and protodolomite at the basin margin followed by reworking and transport of the carbonate sediments to the basin center, as other workers have recently proposed for their playa-lake model.

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MINERALOGIC EVIDENCE FOR BURIED HYDROCARBONS—NEW EXPLORATION TOOL

Imperfect rock seals above petroleum deposits may allow large volumes of low-molecular-weight hydrocarbons to slowly leak and diffuse to the surface. The seeping hydrocarbons chemically alter and incorporate into near-surface and surface rocks as pore-filling cements that are isotopically and chemically distinctive and geographically identifiable because their compositions and densities markedly contrast with surrounding rocks. Strong empirical evidence indicates that gases diffuse directly through the overburden, and leakage of liquid hydrocarbons is controlled by salinity variations in formation waters which affects their solubilities and promotes chemical reactivity. Highly reducing hydrocarbons and associated compounds cause discoloration of surface strata by reduction and dissolution of iron. Near the surface, hydrocarbons are oxidized; expansion of depressurized gas evaporates ground waters concentrating and precipitating dissolved solutes with unique isotopic signatures.

Such alteration and mineralization phenomena have been documented in outcrops of a Permian redbed sequence overlying several prolific oil accumulations in southern and central Oklahoma, but especially at the Cement anticline. Recognition of similar phenomena elsewhere could lead to new discoveries.

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EVAPORITE DEPOSITS OF NORTHERN GREAT PLAINS: COMPARISON OF DEPOSITIONAL SETTINGS

The stratigraphic succession in the northern Great Plains is punctuated by many evaporite deposits of varying thickness and areal extent. They are most predominant in rocks of Paleozoic age and particular in the Devonian and Mississippian Systems. The youngest known deposits are associated with redbeds which have been assigned Late Triassic to Early Jurassic ages. Most of the evaporites in the northern Great Plains are composed of calcium sulfate; halite is somewhat less common, and there are small amounts of soluble potassium chlorides.

Recent geochemical investigations of the distributions of $Sr^{+2}$ in modern evaporites and brines indicate that the mass ratios of $Sr^{+2}/Ca^{+2}$ in calcium sulfate deposits may be employed to assist in the identification of the hydrologic environment in which an evaporite was precipitated and indirectly to distinguish depositional settings. The data from these investigations have been applied to selected evaporites in the northern Great Plains and corroborate the interpretations of the depositional settings as obtained from an examination of the lithologic associations.

The brines from which the evaporites in the northern Great Plains were precipitated may be thought of as having existed in one of two hydrologic environments: (1) interstitially in siliciclastic or carbonate sediments, or (2) as standing water in topographic depressions that underwent intermittent replenishment by less saline waters. The depositional settings as interpreted from lithologic associations and the results of geochemical analyses include: (1) arid supratidal flat, (2) barred-marine basins, ranging from structur-