TV borehole cameras have many geological and engineering applications. In dry uncased holes, uses include determination of lithologic character and stratigraphic contacts, measurement of bedding and fracture orientation, identification of textural features (porosities), and establishment of causes of drilling problems including recognition of caved zones and intervals of circulation loss. A TV camera survey supplements or replaces coring. If hole walls are clean, inspection of the entire interval provides direct information normally lost where core recovery is poor. In holes containing buckled or perforated casing, lost tools or unknown obstructions, a TV traverse may guide the driller to an effective, time- and cost-saving remedy.

The Lawrence Radiation Laboratory has built two cameras for use in pre- and post-shot studies associated with underground nuclear explosions. These 2½-inch-diameter cameras can reach 3,000-foot depths and will operate in vertical or inclined holes up to diameters limited only by illumination capability. Both cameras have remote-control focussing. One camera, having a fixed side-viewing mirror, is equipped with a specially designed compass. The other camera looks down the axis of the hole. Field experience with these cameras is described and photos of the monitor image illustrate the results obtainable during in-hole operation. TV pictures showing the Gnome explosion cavity are compared with actual photographs taken inside this void.

The current status of TV borehole camera technology and possible future developments in both instrumentation and applications are reviewed.

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DEVELOPMENT OF THE COMMAP SYSTEM

COMMAP is an automatic mapping system. It uses an automatic map reader for digitizing the input data, an IBM 704 computer for processing the data and a Benson Lehner Electroplotter for plotting and contouring the output. This system processes, plots, and contours all mappable data. Computations which can be preformed by the system include the following: (1) determination of regionals and residuals by polynomial surface-fitting techniques, (2) determination of regionals and residuals by various ring-average methods, (3) upward and downward continuation of potential field data, (4) first and second vertical derivatives by several methods.

This paper covers the system in general and gives examples of tabulated, plotted and contoured output of the results for a number of specific field problems.

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VERTICAL PETROGRAPHIC VARIABILITY IN ANNOT SANDSTONE TURBIDITES

A wide range of mineralogical and textural variations was observed between the base and the top of marine Tertiary Annot Sandstone turbidites in the Lac d'Allos region of the French Maritime Alps. This variability may be related to the characteristic vertical distribution of grain sizes and shapes within such graded deposits. Relative percentages of most light and heavy minerals and of the primary matrix, as well as factors of sphericity and roundness, are directly related to grain size. Thus the upward decrease in grain size and increase in grain sorting is reflected in a progressive change in rock composition. Samples (43) were collected at 4-cm intervals between the base and top of four well graded turbidites, each less than one meter thick, and these were compared with spot samples (125) collected from a 250-m flysch section. The range of petrographic variability within a single turbidite is as great as the range of mineralogic and textural variations between the base and the top of the formation. The same minerals are found in each turbidite, indicating that source areas and eroded parent rock materials accumulated nearshore remained the same during the period of this formation's history. However, notable variations between succeeding turbidites were noted. This may be explained by the fact that each turbidity current is characterized by its own specific density and velocity gradient. As a result, differing proportions of particle sizes settled out of each suspension flow over the same spot on the ocean floor. Even though gravity currents are able to transport identical sedimentary materials from nearshore environments into the deeper basin, such quantitative variations should be expected in any formation composed of turbidites.

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ELECTRON MICROSCOPE STUDY OF ARAGONITE CRYSTALS IN MARINE SEDIMENTS

The occurrence of aragonite needles in the carbonate mud of the surface sediments of Florida Bay, the Florida Keys, and the Great Bahama Bank is of interest to problems of carbonate deposition. Older views regarding the origin of the aragonite needles support inorganic precipitation. More recent theories favor a biogenic formation and link the mud particles to the aragonite sheath of algae, mainly *Penicillus*, *Rhipocephalus*, and *Halimeda*. Electron microscope studies of mud suspensions and of aragonite crystals from *Penicillus* reveal a remarkable similarity between the aragonite formed on the algal surface, and the aragonite in the carbonate mud. Surface replicas of aragonite sheath peeled from *Penicillus* show needle-like crystals scattered between a network of fiber- or film-like algal material. The closely interwoven system of plant material and aragonite needles supports the suggestion of the algal substrate acting as a matrix for the aragonite formation.

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LATE MISSISSIPPIAN RHYTHMIC SEDIMENTS OF THE MISSISSIPPI VALLEY*

Late Valmeyeran and Chesterian sediments that repeatedly filled the subsiding Illinois basin are a quarter autochthonous carbonate, a quarter sand, and half mud brought from remote northeastern sources by a major river system, the Michigan River. These are arranged in cycles implying shoreline fluctuation landward (northeastward) and seaward through a range of a few hundred miles. About 70 minor reversals in shoreline movement are superimposed on about 15 major cycles. Increases in competence, perhaps in phase with modest lowering of sea-level, repeatedly changed the Michigan River into a prograding stream, pushing its delta scores of miles across a marine basin only a few tens of feet deep. Advancing distributaries carved grooves well below sea-level through frontal and lateral mud banks—grooves later filled by elongate sand bodies analogous with modern barfingers and pass fillings. In late stages the delta supported land vegetation. The carbonate phase

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of the cycle was initiated by decrease in stream competence and continued basin subsidence. Changes in sea-level and stream competence depended on climatic variation.

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SCALED-UP MODEL IN STUDIES OF SEDIMENT TRANSPORT

The study of sediment transport has been handicapped greatly because most of the pertinent processes are too small and too fast to be observed, controlled, and measured. This is the reverse of the problem which confronts the student of tectonics: the processes which he wishes to clarify are too large and too slow to be observed, controlled, and measured. He attempts to solve this problem by scaling *down* the phenomena involved, building scaled models in which the model ratio of length is commonly on the order of 10-4 to 10-8, and other model ratios are set accordingly. The sedimentologist who would like a closer look at sediment transport can apply the same general methodology.

Scaled models have been employed, in the general field of hydrodynamics, for many years. The usual practice, however, is to select a reach of a river, or a stretch of beach, or a complete estuary, or perhaps even a complete ocean, and scale this study area *down*. In order to examine, in detail, sediment transport, the geologist must be prepared to design, build, and operate devices in which the model ratio of length is about $10^2$: that is, he must scale *up*.

Consider a grain 0.4 mm in diameter. With a ratio of length $= 10^2$, one can design a grain which should behave as the tiny prototype does. The model grain will have a diameter of 4 cm. The shape and surface markings ideally should duplicate the original, and the density can be adjusted if necessary. The remaining criterion which must be satisfied is the Reynolds number, which involves fluid viscosity.

Once a few trials have been made, the experimenter can alter his variables so that more favorable velocities and viscosities are used. This alteration can be pushed until a change in behavior sets a limit; thereafter, all runs must be made on the correct side of the limiting value, but without necessarily matching the precise requirements of the model ratios. This permits considerable freedom in design and operation of the models.

Models of this kind show that turbulent regime holds, for settling grains, for Reynolds numbers of about 10, and more. The triple vortex trial which developes behind (above) the grain imparts both a spin and a spiral motion to the grain. Similar models can be operated and evaluated for grain pick-up.

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DIMPLE LIMESTONE—A TURBIDITE SEQUENCE

Recent work on the Dimple Limestone (Atokan) of the Marathon tectonic belt of West Texas indicates that it is predominantly a turbidite sequence deposited in relatively deep water below normal wave base. A narrow upperslope facies of nongraded, festoon cross-stratified grainstone, packstone, and chert conglomerate beds deposited in relatively shallow water occurs in the northwest part of the area. Wherever exposed, the formation is part of an overthrust complex which moved northwestward a distance of several miles or more.

The basin facies to the southeast consists of interbedded pelagic and turbidite beds. The pelagic beds are dark gray to black terrigenous shale, calcilutite, and chert containing a sparse fauna of radiolaria and sponge spicules. The turbidite beds are graded lithoclastic fossiliferous limestones ranging in thickness from less than an inch to more than 9 feet. Lithoclasts are mostly angular fragments of Devonian and Ordovician cherts. The fauna is characteristic of shallow shelf and slightly deeper slope environments, and indicates redeposition by turbidity currents. Small quantities of ooliths, pellets, glauconite, and quartz sand grains occur commonly in the turbidite beds.

The turbidite beds contain current direction features including aligned fossil fragments (particularly sponge spicules and brachiopod spines), cross laminae, ripple marks, and flame structures; and slope indicators such as convolutions and medium-scale slump structures. Sole markings are not evident. Delicate laminae in upper parts of graded beds commonly consist of siliceous sponge spicules aligned parallel with the current direction.

Numerous measured sections of the basin facies indicate a record of continuous deposition from the flysch-like Tesnus Formation, through the Dimple Limestone, and into the overlying flysch-like Haymond Formation. Submarine slides containing large blocks of white Devonian chert locally produced erosional surfaces. A comparison of the Tesnus Formation, Dimple Limestone, and Haymond Formation with the Scaglia-Brecciola-Macigno sequence of the northern Apennines shows striking similarities.

Current direction indicators, bed thickness, grain size, facies, and over-all formation thickness indicate that the Dimple Limestone was transported down a slope from the northwest. During early Atokan time, a carbonate shelf in the vicinity of the Glass Mountains provided shallow-water fossils and other carbonate debris for later redeposition in a relatively deep basin on the southeast.

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EXAMINATION OF THE ULTRASTRUCTURE OF SOME FORAMINIFERAL TESTS

Foraminiferal tests have been studied in the electron-microscope using carbon replicas. Thin sections of the tests have been studied in transmitted and polarized light and phase microscopy. Miliolids show two intergrading kinds of surficial ultrastructure; some areas are made of numerous oriented rhombs of calcite, presenting a pattern resembling a tile roof; other areas show randomly distributed rods of calcite. In phase microscopy, sections of the miliolid test present a furry appearance. *Peneroplis planatus* shows a more massive surficial ultrastructure, and presents a different appearance in polarized light, certain layers having oriented calcite crystals. *Nodosaria affinis* and *Robulus midwayensis* have perforate areas with about 50 pores per 100 square microns surface area, each pore being about $\frac{1}{2}$ micron in diameter. Imperforate areas of these tests are made of relatively large crystals of calcite, up to 2 microns in diameter. Sieve plates have been found covering the ends of pore canals in *R. midwayensis*. *Sphaeroidina bulloides* and *Bulimina marginata* are strikingly similar in their ultrastructure. They have about 40 pores per 100 square microns surface area. The pores average $\frac{1}{2}$ micron in diameter. *Discorbis vesicularis* has a rough surface, and only about 4 pores 2 microns in diameter per 100 square microns surface area. *Elphidium macellum* has a finely finished surface and 120 pores $\frac{1}{2}$ micron in