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COMPUTER CORRELATION OF GEOPHYSICAL LOGS

Interpretation of subsurface geology commonly depends on correlation of geophysical logs. In its simplest form, the process of correlation involves visual matching of similar characteristics on several logs. In regions where strata do not thicken or thin, correlation simply involves shifting one of the logs relative to the other until common characteristics are aligned. Variations in strata thickness, however, complicate the procedure and emphasize a need for computer analysis.

Automatic correlation of logs by computer techniques depends on utilizing the mathematical concept of a cross-correlation function. Position of the maximum value of the function identifies the amount of shift. Correlation of logs with varying thicknesses of strata involves a 2-step process. First, 1 log is resampled mathematically at an expanded or stretched interval, and then the stretched log is used in the cross-correlation process.

Models simulating geophysical logs demonstrate computer capability to compute shift and stretch. Computer output consists of a plotted reproduction of 2 logs with correlation lines connecting similar strata in each log. Applications to real well data in Indiana support visual correlations suggested by subsurface stratigraphers. Copies of the computer program can be obtained from the Indiana Geological Survey.

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NAVIGATION, FIELD OPERATION, AND IMAGE-PROCESSING TECHNIQUES FOR THERMAL INFRARED IMAGERY SURVEYS

Numerous reports have demonstrated the applicability of thermal infrared imagery surveys to geologic, environmental, and agricultural problems.

Most thermal infrared imaging for geologic purposes is flown at night to avoid the effects of differential solar heating. Existing aeronautical navigation aids are designed for point-to-point flights rather than the precisely spaced and oriented parallel flight lines required to cover a project area. The traditional method of navigating nighttime imagery flights requires personnel with signal lights to occupy a sequence of ground control points and this method has numerous drawbacks.

A newly developed aircraft navigation system utilizes the 9 very low-frequency U.S. Navy radio transmitters located around the globe to fly very accurate courses with no ground aids. Using this system at night to navigate from the base air strip to a known starting point within the project area, parallel survey lines up to 50 mi long have been flown with precise spacing to obtain the necessary imagery sidelap for preparing mosaics. Comparison of actual aircraft flight lines (obtained by plotting nadir line of imagery onto a map) with the programmed flight lines indicates a satisfactory agreement. The navigation system also provides real-time readout of true ground speed which is essential for processing of imagery magnetic tapes.

After solving the navigation problems, the flight program is designed. Each project area has unique combinations of terrain and geology that require special consideration, but some generally valid concepts have been established. Normally the orientation of the structural grain of an area is known before the survey. Flight lines should not cross the structural grain at right angles because subtle linear patterns may be obscured by the closely spaced scan lines on the imagery. Selection of flight altitude above average terrain elevation is a tradeoff between imagery spatial resolution versus imagery scale and ground coverage. Cost is also a factor, for at higher flight altitudes the ground coverage is greater and fewer flight lines are required. Atmospheric attenuation of the infrared signal at higher flight altitudes must also be considered. As a practical guide to altitude selection, imagery of the same flight line at altitudes ranging from 1,000 to 8,000 ft above terrain is shown.

Thermal infrared imagery has been improved greatly by recent advances in electro-optical technology and solid-state physics. Doped germanium detectors which required closed cycle cryostats or liquid helium cooling have been replaced with tri-metal detectors which operate with simple liquid nitrogen cooling to obtain imagery in the 8–14 micrometer wavelength region of greatest geologic significance. Quantitative scanners are now available in which gray-scale variations are calibrated to exact temperature values rather than relative temperature variations.

Early airborne scanners which recorded imagery directly on film had many disadvantages. Modern scanners record the imagery on magnetic tape which is later played back onto film in the laboratory. The magnetic tape may be replayed to obtain optimum imagery contrast and to adjust the scale for any variations in aircraft ground speed. Conventional scanner imagery is compressed and distorted at the margins because of the geometry of the system. The magnetic tapes, however, may be processed with a secant-square function to produce rectilinearized imagery with constant scales in the X and Y directions. Various image enhancement techniques also may be applied to the tapes, such as level slicing, digitizing, and conversion to color display for greater resolution of subtle thermal differences.

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DIAGENETIC CHANGES IN ULTRASTRUCTURE OF SKELETAL CARBONATES FROM PLEISTOCENE OF SOUTH FLORIDA

Scanning electron micrographs of skeletal carbonates (mollusks, corals, barnacles, polychaete annelids, bryozoans) from the Miami and Key Largo Limestones (south Florida) provide unequivocal evidence for *in situ* conversion of skeletal aragonites. Many of the petrographic criteria for such conversion have been regarded as uncertain; presence of inclusions reflecting former skeletal structures is more reliable evidence of direct conversion than solution-infill mosaics. In converted aragonites, coarse calcite mosaics contain submicroscopic remnant crystallites of the original aragonitic ultrastructure. These remnant crystallites are in original orientation, as solid inclusions in the calcite grains. Partially altered shells traversed by advancing diagenetic fronts demonstrate the continuity of orientation of the crystallites in the unaltered aragonitic shell layers with the aragonitic solid inclusions in the calcite mosaic behind the front. Mineralogy of the respective grains and crystallites was verified by means of Feigl solution, an aragonite-specific stain.

Calcite ultrastructures are commonly little affected, but in *Schizoporella floridana* (Bryozoa) from the Miami Limestone, the calcitic primary skeleton is recrystallized, although the calcite mosaic of converted superficial frontal aragonite layer still contains solid inclusions of the original aragonite.

The presence of such aragonite inclusions, or the numerous pits which result when they are dissolved (*e.g.*, during etching or Feigl solution treatment), may be useful in recognition of older examples of *in situ* conversion of aragonites.

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PALEOGEOLOGY IN 21ST CENTURY

When the archivists of the 21st century dig back into the history of the science of the earth, they will fail to see some of the distinctions of which we today are acutely conscious. Geology, geophysics, geochemistry, paleontology, and their brethren will have blurred into a single mature and rather noncontroversial discipline.

We can expect that the various earth sciences of today will continue to undergo the accelerating maturation processes that have been followed in the older sciences. The trends are clearly visible today—the descriptive and taxonomic in geology, the intuitive and subjective in geophysics are surely losing ground to the postulational and mathematical approaches of physics and chemistry. Today much of our basis for differentiation among earth sciences lies not in what those scientists are studying but in the tools that they use. Such distinctions cannot prevail. By the 21st century (only 29 years away), the successors of today's geological journals will be as full of mathematics as are today's geophysics journals. The neo-geophysical journals will be steeped in geological ideas.

Those of us in both fields who fail to adapt to the new trends will be available as subjects of study by the paleoscientists of the next century for we shall surely be fossilized.

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GEOLOGIC HISTORY OF BLUE-GREEN ALGAE: A PARADIGM OF EVOLUTIONARY CONSERVATISM

Approximately 185 occurrences of fossil blue-green algae (excluding stromatolites and similar organo-sedimentary structures) have been reported since 1855. More than half of these occurrences have been described during the past 5 years and more than 75% since 1950. This recent, major expansion of the known cyanophytic fossil record is a direct result of the recent upsurge of interest in Precambrian paleobiology; nearly two thirds of all occurrences and 95% of those reported during the past 5 years are of Precambrian age. The majority of reported fossil cyanophytes are cellularly preserved in microcrystalline cherts. Evidence of ecologic setting, growth habit, general morphology, detailed cellular anatomy, and mode of reproduction is rather commonly present. Comparison of fossil and living taxa indicates that in all of these features, and presumably in ultrastructure and biochemistry as well, many of these primitive prokaryotes have evolved little or not at all since the Precambrian. The marked evolutionary conservatism of the Cyanophyceae is attributable to the wide ecologic tolerance, versatile physiology, and unusually stable genetic system characteristic of the class; a suitable ecologic niche, relatively free from competitors, has been accessible to these highly adaptive microorganisms since early in earth history. Evidence now available suggests that the earliest blue-green algae were unicellular coccoids, first appearing during the early Precambrian; that mat-building, filamentous cyanophytes had become established as early as 2.8 b. y. ago, that the class reached its zenith in evolutionary diversification and ecologic importance during the late Precambrian; and that the subsequent appearance of heterotrophic, mobile eukaryotes (protozoans and metazoans) resulted in adjustment of ecologic relations and a marked reduction in distribution and abundance of cyanophytic communities early in the Paleozoic.

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GEOLOGIC IMPLICATIONS OF RIVER-PATTERN VARIABILITY

Experiments were performed in a large flume at constant discharge to determine the effect of slope on channel patterns. At very low slopes ($<0.2\%$), the model channels remained straight, but a meandering-thalweg channel formed at steeper slopes (between 0.2 and 1.3%), and braided channels formed at the steepest slopes ($> 1.3\%$). These experiments demonstrate that channel patterns can change from straight to meandering to braided at critical values of slope.

The results also are applicable to the problem of the downstream variability of river patterns. Most alluvial rivers flow on surfaces (valley floor or alluvial plain) whose slopes have been determined by past conditions of flow and sediment load, by tributary effects, and/or by warping. As channel patterns are sensitive to changes of slope, other conditions being similar, a steeper reach of valley slope usually will cause an increase in channel sinuosity, as the river attempts to maintain a relatively constant gradient. Experimental results and Mississippi River data support this conclusion, which may be of practical value in identifying reaches of a river system influenced by neotectonics or structure.

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GEOLOGY OF WAGON WHEEL NUCLEAR STIMULATION PROJECT

Project Wagon Wheel, if executed will be an attempt to stimulate gas reservoirs of the Pinedale anticline by means of nuclear explosives. The Pinedale field, located in the northern Green River basin of southwest Wyoming, is potentially productive from a section totaling nearly 10,000 ft of lower Fort Union, Lance-Lewis, and Mesaverde sandstone equivalents. Attempts to produce the field conventionally have proved uneconomical due to low permeability.

Because its requirements exceeded the state of nuclear technological development, Wagon Wheel was not selected for the first gas stimulation experiment. Project Gasbuggy, in northwest New Mexico, was detonated in 1967 using a 26 kiloton device. Data produced in Gasbuggy were utilized in planning Wagon Wheel, which is an actual attempt at economic use of nuclear energy.

Wagon Wheel No. 1 was drilled to 19,000 ft to evaluate the entire Mesaverde section. Gas was detected by mud-logging equipment below 7,972 ft depth throughout the basal Fort Union, Lance-Lewis, and Mesaverde. The well has been plugged back to 11,700 ft leaving approximately 3,700 ft of proved gas-bearing section available for stimulation. This interval will accommodate the 5 100-kiloton explosives planned. In-place