Composite Spectral Gamma Ray Log of the Goodland Formation Fort Worth, Texas

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1. Abstract

In this study a portable gamma-ray spectrometer was used to measure the radioactive contents of carbonate-shelf sediments of the Goodland Formation at four outcrops. The aim of this study is to observe the distribution of potassium (^{40}K), uranium (^{238}U) and thorium (^{232}Th) in several corresponding outcrops in Tarrant County, and to investigate the potential uses of gamma-ray spectrometry in correlation and facies discrimination on an outcrop scale. This study evaluates the degree of accuracy and precision of the Spectral Gamma devise in coordination with the ability to reproduce good scientific data from the outcrops on the surface. Research was conducted along three corresponding outcrops on Trinity River embankments, and at the Lake Benbrook spillway, where the Goodland Formation crops out. This research indicates that in order for the spectral gamma ray tool to produce reliable data sets, the spectrometer must run for multiple intervals over the study area, while decreasing the amount of interference as much as possible.

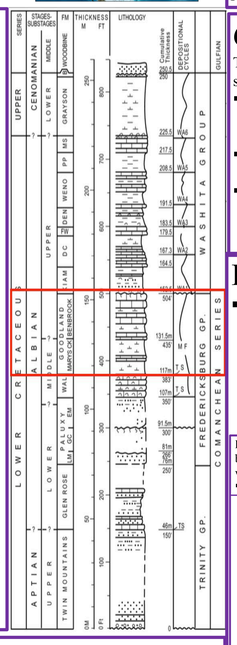
2. Study Area

Research was conduced in Tarrant County, Fort Worth, Texas. Three of the areas are located along the Trinity River: the first at Press Café, off of Edwards Ranch Road near Clearfork, and the second and third where the Bryant Irving and Chisolm Trail intersect the river. The forth study area is located below the Lake Benbrook dam in the spillway, off of Arborlawn Drive.

- Location 1. Press Café: 32°42'21.37"N, 97°23'40.77"W.
- Location 2. Bryant Irving: 32°42'16.89"N, 97°24'40.71"W.
- Location 3. Chisolm Trail: 32°42'22.45"N, 97°24'3.39"W.
- Location 4. Lake Benbrook Spillway: 32°39'17.19"N, 97°26'52.91"W.

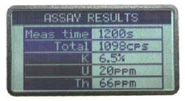
3. Depositional History

- The Goodland Formation was deposited about 108 million years ago on the Texas Platform, where the Western Interior Seaway initiated connection with the ancient gulf.
- The Fredericksburg Group in the Trinity Valley represents a single, long term depositional cycle of deepening and shallowing of the Comanche Shelf.
- The Goodland Formation is locally divided into the Lower Marys Creek Marl Member and the Upper Benbrook Limestone Member.
- The Marys Creek Member overlies the Walnut Formation with a transgressive surface marked by a thick oyster shell bed.
- The Benbrook Limestone overlies the Mary's Creek at the Maximum Flooding interval.
- The top of the section represents an upward shoaling sequence, where sea level lowered and wave energy increased.
- Ammonite assemblages indicate that the North Texas basin was connected with the open ocean during the deposition of the Goodland Formation.
- The certain zones of abundance of ammonites and echinoids are most reliable for determination of stratigraphic level, while other fossils are variable in value.
- The Goodland dips a gentle 10º to the southeast.



4. Methods

Data was collected using the RS-230 BGO portable spectral gamma ray tool to measure the radioactive elements of U, Th, and K throughout four outcrops. The RS-230 BGO Gamma-Ray Spectrometer/ Scintillometer is a state-of-the art, portable hand-held radiation survey search device for the geophysical industry. It offers an integrated design with a large detector, direct Assay data, data storage, full weather protection, ease of use and highest sensitivity in the market segment. The spectrometer is auto-stabilizing on the naturally occurring (K, U, & Th) radioactivity and does not require any test sources.



Tool Specifications

- Assembled in a flashlight style devise
  - Power button
    - Requires 4 AA batteries
    - Life: 8+ hours
  - Thumb activation to begin time
  - Bluetooth compatible
  - Fully water and dust resistant housing configuration
  - Readings graphically configured on screen
    - Search Mode: Counts in CPS from 0 to 65,535 and Histogram chart
    - Assay Mode: Display in %K, ppm of U & Th (ROIs per IAEA)
  - Survey and Scan Modes
    - Total Count readout at a 1x / sec. rate in the Survey Mode or variable (1 – 20 sec.) in the Scan Mode.
    - When used with a GPS receiver, data can be stored and profiles produced. Ideal for both area survey and drill core scanning.

5. Field Procedure

Data collection was a methodical process, where the spectral gamma ray tool was placed on a fresh surface of the rock and run in Assay mode for two minutes at six inch intervals.

- At each interval, a fresh, flat surface was created perpendicular to the bedding plane to be measured.
- The circumference of the fresh surface was made approximately equal to the circumference of the tool, allowing it to stay in contact with the fresh surface without outside interference.
- Areas covered by soil, fresh organics or experiencing drainage were excluded from this study to avoid contaminated data.

Once the measuring surface was created, the spectral gamma ray was then stabilized (held in place by hand, etc.) and run in Assay mode for two minutes. The tool's output at the end of the two minute interval displays parts per million of thorium (Th ppm), parts per million of uranium (U ppm), and percent potassium (K %).

- Four readings were taken at each six inch interval to allow the tool's data values to normalize and account for minor variations within the data set.
- While this test was occurring, other rock characterization methods were conducted which consisted of litho-facies descriptions, noting significant contacts, and sedimentary structures, fossil assemblages and conducting an HCL Acid test.

After collecting the data in the field, the data values were recorded in Excel tables, where gamma ray log plots were created.

6. Spectral Gamma Ray Characteristics

The Gamma Ray is an important tool for the petroleum geologist as it measures the natural radioactivity of rocks and can be used both on the surface and in the subsurface to distinguish lithology and formation contacts.

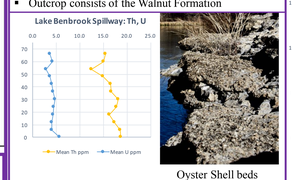
- The gamma ray log is widely used to interpret grain size profiles in sedimentary successions.
  - Values are observed to increase with decreasing grain size in proportion to the amount of clay minerals present in the formation.
  - However, the gamma-ray reading is *not* a function of grain size but of mineralogy,
- The natural gamma-ray spectrometry log is a considerable improvement on conventional total-count gamma-ray logs as it measures the elemental concentrations of the three main contributors to natural radioactivity, *ie* potassium (^{40}K), uranium (^{238}U) and thorium (^{232}Th).
- When recorded in the subsurface, values are often taken between 1-5 foot intervals, which allows for micro-scale features to be overlooked during log interpretations. In this study, gamma ray measurements were taken every six inches to compose a detailed surface log that marks significant formation contacts.

Final Interpretations

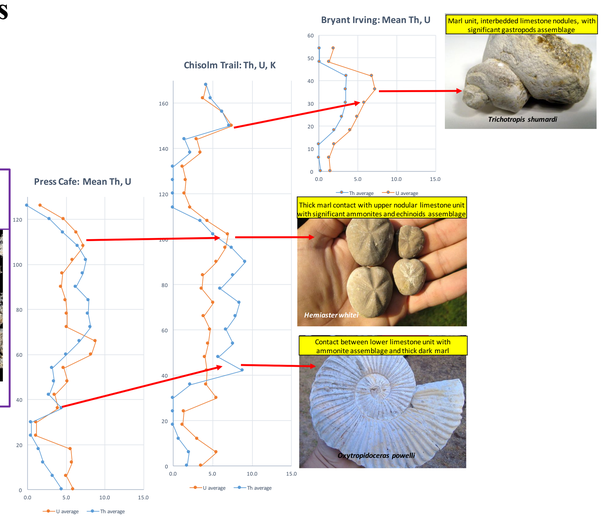
- Correlations based on:
  - Lithology and contacts
  - Fossil assemblages
  - Gamma ray values

Lake Benbrook spillway outcrop could not be correlated based on lithology, fossil assemblage or gamma ray values

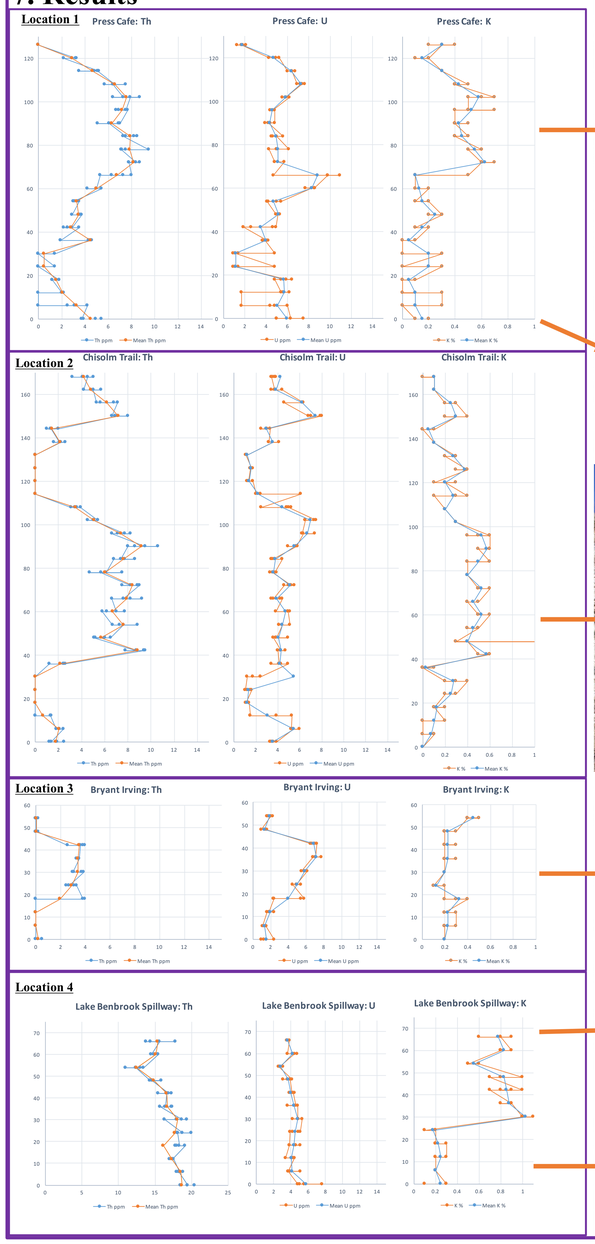
- Outcrop consists of the Walnut Formation



Oyster Shell beds



7. Results



8. Interpretations and Discussion

From the plotted results, the three outcrops along the Trinity River are correlated in respect to their regional location, the overlapping of lithologies, significant fossil assemblages, and the similar highs and lows in the recorded Th, U and K values. The forth, Lake Benbrook Spillway location could not be correlated successfully due to the lack of similar lithologies or fossil assemblages, and higher thorium content, not consistent with the other three locations. The final interpreted composite log does not include the Lake Benbrook data set, as the measured section was found to be primarily composed of the underlying Walnut Formation, where the Th, U and K values could not be successfully correlated to those found at the Trinity River locations. The significant lithologic units at the Press Café and Chisolm Trail locations were correlated by the presence of ammonites (*Oxytropidoceras powelli)* within the lower and upper limestone beds, and the concentration of echinoderms (*Hemiaster whitei*) along the contact between the thick marl unit and upper limestone unit. The Chisolm Trail and Bryant Irving sections were correlated by the concentrated abundance of gastropods (*Trichotropis shumardi)* and similar bivalve assemblages as well as the common nodular limestone litho-facies.

9. Conclusions

This research illustrates that the Spectral Gamma Ray tool successfully identifies formation contacts on the micro-scale testing area when run in assay mode for at least three to four repetitions. When the tool was run for a single rep/per measured interval, the values did not normalize correctly and led to non-reproducable data sets. The tool proved to require an unweathered measurement surface, in order to calculate correct Th, U and K values.

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