Log jammin': transforming well logs to music

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SUMMARY

Physical data, such as radioactivity measurements on a Geiger counter or well-log values, can be mapped to audible sounds using various transformations. This process, sometimes called sonification or audification, can provide a sequence of sounds that have an interpretable or even musical quality. We use well logs from the Blackfoot oilfield of southern Alberta and the White Rose oilfield of offshore Newfoundland, in an audification process, to create somewhat musical pieces. The audible realization of well logs may provide an alternative realm for petrophysical interpretation which could enable more immediate recognition of various lithologic conditions. This procedure may also prove useful for disabled log analysts as well as in general education and entertainment.

INTRODUCTION

The transformation of various phenomena to audible sounds or music may be interesting or even useful. Production of sounds from information traditionally expressed by visual tools like graphs or tables has become known as sonification or audification (Wolman, 2001). Boyle and Grimes (2005) discuss the transformation of various astronomical phenomena, including the cosmic microwave background, to audible sound for educational purposes. Some large-scale astronomical processes produce sounds themselves. Further attention has been paid to the computer analysis of music. Rhythm alone can be computer analysed to identify a song (Bridge, 2006 and see www.songtapper.com), or its musical identity (Kirovski and Attias, 2002). Musical compositions have been based on physical or mathematical phenomena; such as the arrangement of notes in a Fibonacci sequence (APEGGA, 2006); the variable concentrations of solar particles, earthquake activity, climate oscillations as recorded in arctic ice cores (Quinn and Meeker, 2001); and changing shape of fossils to determine palaeontological patterns (Ekdale and Tripp, 2005).

A prime motivation for our work in this well-log audification process includes possible assistance for visually disabled individuals who may be able to hear as opposed to see and could perhaps accomplish an aural analysis of data. Mapping physical phenomena into the making of music is inherently fun for some and is of educational interest. It may be possible to assess data without directly looking at it - perhaps leading to a faster identification of some anomalies (such as the immediately recognizable clicks of a Geiger counter). It has been said that geography can influence musical composition (Harris, 2006), but can geology actually create music? We explore this possibility in the following work.

METHODS

Our method relies on mapping or transforming well-log values into musical notes. There are a number of characteristics of musical notes: pitch, attack, volume, duration, attachment, timbre. Putting notes together into something that could be described as music, includes arranging the notes in some structure with a tempo or speed, rhythm, harmony (multiple, simultaneous according notes), and chord progressions. We take logs and map their values directly to a pitch. We give each log a voice or timbre. These notes are played together. There are infinitely more sophisticated methods. For example, we could use one log for volume, use derivatives or other attributes of another log to map to volume or attack. Use one log to modulate pitch or provide a chord progression.

We use well logs, from two hydrocarbon provinces in Canada, to create somewhat musical representations. The Blackfoot oilfield of southern Alberta provides a continental example and the White Rose oilfield offshore of Newfoundland (Figure 1), an oceanic case. The Blackfoot oilfield example focuses on the number of different transformations that could be represented. The White Rose oilfield example explores resolution and some of the more successful data transformations. Well log data from a variety of measurements (including - sonic, SP, porosity, gamma, resistivity) were mapped to a number of musical attributes (Table 1). These were represented musically using MIDI (musical instrument device interface) properties and Sibelius 2.1.1(musical scoring program). The transformation is further modified by additional log values and algorithms (Table 1). The note series are output as MP3 files.

EXAMPLES

We select the melody line, in the musical mapping effort, to be provided by the primary lithological indicators (resistivity and neutron porosity), while harmony is played by the sonic and density porosity. The SP and Gamma logs are used in a variety of ways to transform other important reservoir attributes into the audible domain. The Blackfoot oil field is found in a Lower Cretaceous channel system. These glauconitic channels, which were repeatedly incised into parts of the Lower Cretaceous clastics and Mississippian carbonates, are filled with sand or shale. These, in turn, are overlain by coals. The mapped tempo and volume changes may provide the most obvious clues to the lithology types; for example, coal is represented musically by slower and louder bars. The aural interpretation of pitches and instrumental relationships highlights changes in well log data from coals to the glauconite sand (Figure2). It is also possible to assign musical identity to this music. Depth is used as an indicator of rhythm, sounding every bar to guide the listener towards a meaningful interpretation. Pseudo beats are mapped from the peaks and troughs of data within each pseudo bar. This rudimentary “beat identification” reveals trends in stressed beats such that a style may be applied to the transformation (Figure 3). The gamma ray, for example, can be used to determine the tonality of the music (Figure 4). We are generally using about four well-log data points every meter, and assign two meters to each musical bar (Figure 5). This should allow resolution of reservoirs a few meters thick and may be musically significant as detectable motifs are often two bars long. Initial transformation of only one data point every meter, would sonify greater depths, offering a “reconnaissance” level of audible perception.

CONCLUSIONS

We have mapped a suite of well logs into a progression of musical notes and "harmonies". There are many possible permutations of the transformations. The assembled logs here not only provide some interesting, even pleasing, moments, but register perceivable changes correlating to petrophysical conditions.

Comparison of the style and musical character between these logs could provide further contrasts or similarities between continental and oceanic areas. This may be purposeful in light of practical petrophysical interpretation, as well as for its educational value.

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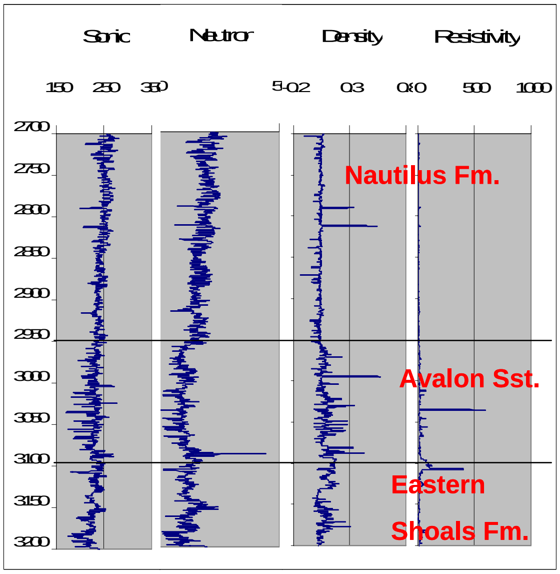	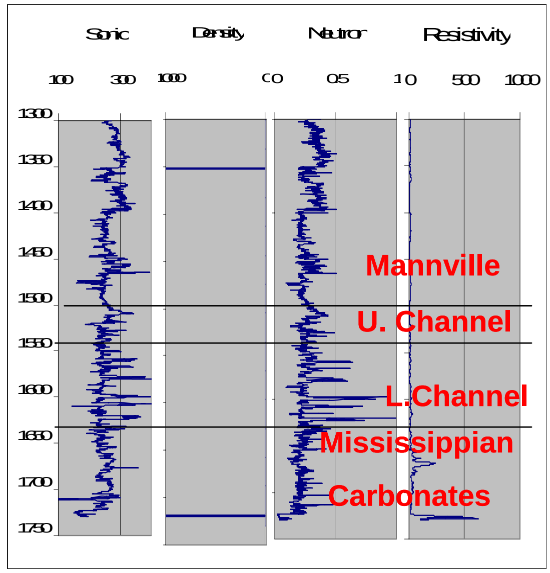
Avalon sandstone in South Mara Unit, White Rose Oil Field.	Mannville coals and Glauconitic Channels, Blackfoot Oilfield.

FIG. 1. Well logs characterizing the White Rose and Blackfoot oil fields.

Table 1. Mapping well log data to musical attributes.

Well log data		Musical Representation
Numeric log values		Pitch(s)
Depth		Time signature/Rhythm
Zones of interest and SP envelope		Volume
Acoustic slowness	Mapped to	Tempo
Gradient of log curve		Attack of note (marcato/slur)
Standard deviation of 10 m intervals		Vibrato/staccato
Porosity		Key/modulation
Data resolution/samples		Style

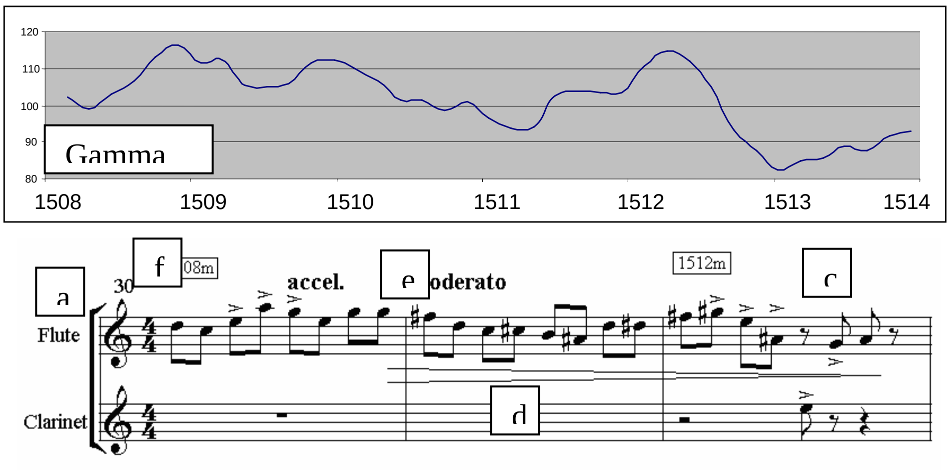

FIG. 2. Mapping of gamma ray (GR) log data to musical score. (a) timbres from tool used; (b) GR value mapped to pitch; (c) increased attack (marcato marks) with increasing gradient of peaks/troughs; (d) changing volume as music plays through different lithology; (e) increasing tempo as seismic velocity increases from coal to glauconite; (f) depth mapped to time signature and bar.

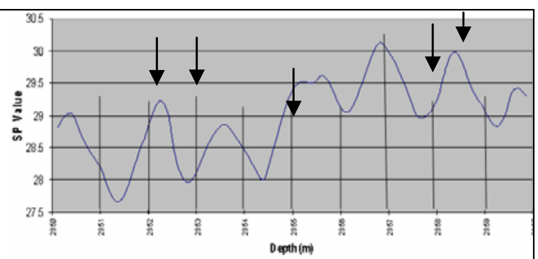

FIG. 3. "Beat Analysis" from SP log (White Rose Oilfield) to determine style of music. Black lines denote the first beat of each pseudo-bar. Note the second and sometimes fourth beat (↓) is emphasized by the peaks and troughs of the data.

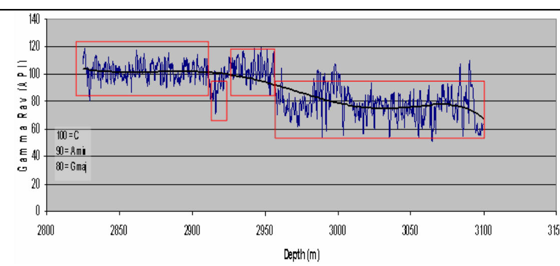

FIG. 4. Selection of harmonic progressions using averaged GR data. The relative change from one set of frequencies to another provides the basis for harmonic progressions. These were pre-selected, following conventional harmonic rules.

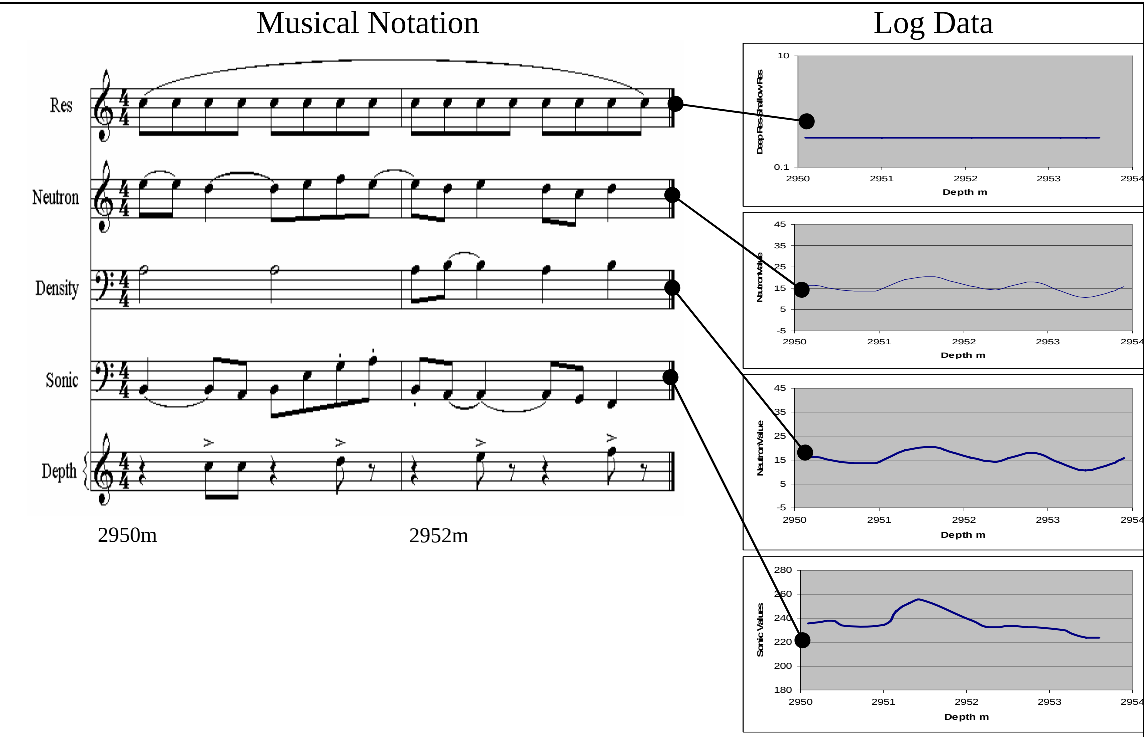

FIG. 5. Example score from White Rose oilfield. Oceanic strata with little lithologic variation, heard by repetitive note of resistivity log. Depth is played here with rising notes, in the style (rock or swing) determined by "beat analysis".