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GC Insights: "Sedimentary Rock!" – A web app that converts geological strata data into music

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Abstract. A web app called "Sedimentary Rock!" has been developed to reveal geological strata to human hearing and rhythmic senses, similar to music, in a straightforward way. A columnar section created on the app is converted to notes and played. The thickness of a layer is converted to the length of a note, and the grain size is converted to pitch level. Sedimentary Rock! makes learners understand that the strata consist of concepts of grain size and thickness of stratum and provides a new intuitive experience to listen to geological history.

1 Introduction

Primary information obtained from geological strata is generally interpreted visually. However, methods other than viewing can be used to interpret geological strata, such as verifying grain size by touch with the fingers and physical surveys where strata cannot be directly seen underground. New techniques and perspectives can interpret strata, which may lead to discoveries and understanding. Our motivation for this study is to convert researchers' and educators' field data to music, and anyone can create music from natural records.

Attempts to make natural phenomena audible that we know as "sonification" converted from atom trap (Sturm, 2001), brainwaves (Sonifyer.org, 2006), the behavior and structure of molecules (Nakamura, 2012; Mahjour et al., 2023), colors (Harbisson, 2012), and molecular evolution (Martin et al., 2024) to sounds.

Especially in the geoscience field, some attempts at "musification" that make music from geoscience data such as volcano seismograms (Avanzo et al., 2010), earthquakes (Sonifyer.org, 2013), climate data (Planetary Bands, 2015; St. George et al., 2017), plasma waves in space (Meredith, 2019), climate model (de Mora et al., 2020), Anthropocene record (Perera, 2020), energy budget (Nagai, 2024), and terrain relief (Lin et al., 2024) are known.

To reveal geological strata to human hearing and rhythmic senses very simply, we have developed a web app, Sedimentary Rock!, which plays music by converting strata thicknesses to note lengths and grain sizes to pitch levels. The web app was opened in 2018 and has been used. It helps anyone understand the cyclicity or drastic changes of geological history recorded in strata and variation in each sedimentary environment.

2 Sedimentary Rock!

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The web app was created with JavaScript and works in web browsers for computers, smartphones, and tablets (Fig. 1a). The general procedure when using the web app is to create and edit a single columnar section in the web app and then convert it to music. The web app may create columnar sections without playing music, and descriptions and remarks can be written in a memo box. The user must initially connect to the Rissho University server (http://rissho-es.jp/kitazawa/SedimentaryRock/), but once the web app has been started up, columnar sections can be created, saved, and loaded, and music can be played, even offline, for as long as the browser window is kept open. Because it is easy for anyone to use freely, it will be helpful in education and outreach activities.

3 Creating columnar sections

A columnar section is created by entering a single layer's thickness and grain size and adding more layers above or below. After the columnar section is created, layers can be freely selected and edited, and further layers can be inserted at selected positions. Thicknesses can be entered in units of m, cm, or mm ranging from 1 mm to 100 m. In the rare case of a layer with a more than 100 m thickness, multiple 100-m sections can be individually added. Grain sizes are entered as selections from eight types—"gravel", "very coarse sand", "coarse sand", "medium sand", "fine sand", "very fine sand", "silt", and "clay"—or "none" (representing a gap or core damage). In a created columnar section, gravel is colored brown, sands are colored yellow, and muds are colored blue. The grain size can be varied between the bottom and top of a layer, which are then interpolated linearly. Thus, grading and reverse grading can be represented. Most grain size variations can be represented by entering separate positions where variation trends change. Other functions include adjusting a columnar section's horizontal width and length to match the screen size or changing its visual impact. Black boundary lines can be displayed at bedding planes, although the default setting does not display these lines.

When information on the thicknesses and grain sizes of a created columnar section is saved, the information is exported in the "Sedimentary Rock Data (SRD)" format that we developed, an image of a pattern of colored squares. SRD is an ordinary image file (PNG), which can be saved in an image folder on a smartphone and sent to other people. A saved columnar section can be loaded into the web app by selecting the corresponding SRD file. A loaded columnar section can continue to be edited and, if saved again, saved as a new SRD file rather than overwriting the old one.

As a result, Sedimentary Rock! is not only a musification app but also a helpful tool for making and presenting columnar sections and straightforwardly managing editable sedimentological data.

4 Converting strata to music

For the conversion of the thickness t (mm) of a layer to the length l (ms) of a note, it is specified that the thicker the layer, the longer the note. In order to handle strata with a wide range of thicknesses, the natural logarithm of the thickness is used, $l=100\log t$. The thickness of each layer can be from 1 mm to 100 m, corresponding to note lengths from 0 to 1151 ms. The C major pentatonic scale (C-D-E-G-A-C) is used to convert from grain size to pitch level. The C major pentatonic scale is often used in rock music and other genres; it tends not to produce unpleasant sounds because it has no semitone intervals. Eight tones starting from A at 440 Hz are specified such that the smaller the grain size, the higher the pitch. That is, gravel is A, very coarse sand is C, coarse sand is D, medium sand is E, fine sand is G, very fine sand is high A, silt is high C, and clay is high D. "None" is represented by silence.

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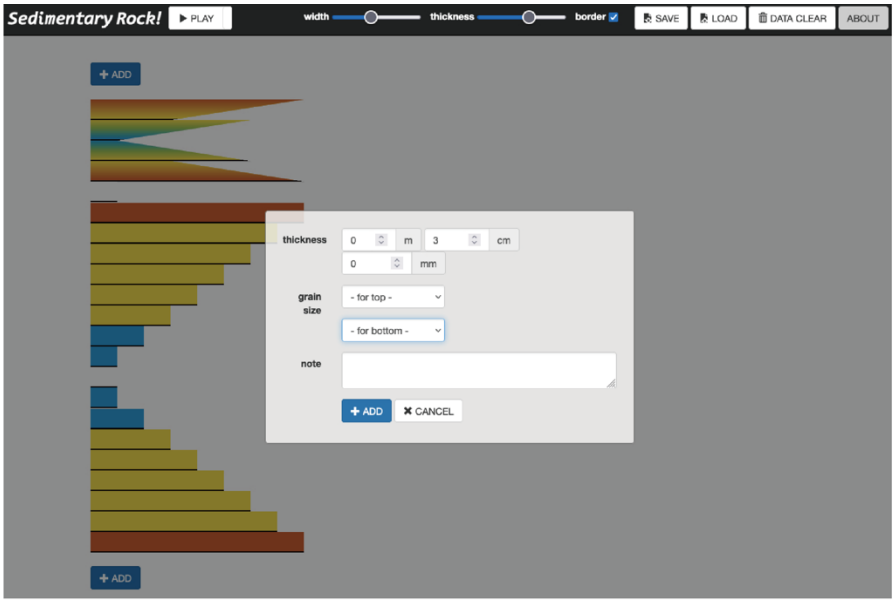
When the Play button is pressed, the columnar section, starting from the bottom, is converted to notes and played. This sequence of sounds can be listened to as music (whether it actually "rocks" is another matter), and the strata can be heard. The music would need improvement to sound pleasant, but the basic objective of revealing geological strata to human hearing and rhythmic senses is achieved.

We share a video on how to use Sedimentary Rocks! and several examples of musification from schematic columnar sections of typical depositional environments of the delta, wave-dominated coast, tidal flat, and submarine fan (https://www.youtube.com/@SedimentaryRock-e7r/videos).

(a)



(b)

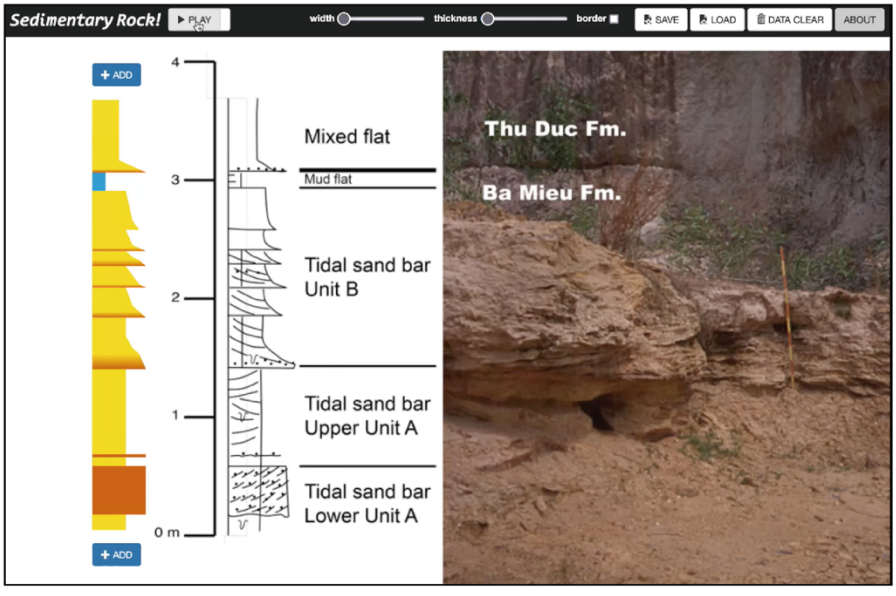


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Figure 1. (a) Interface of "Sedimentary Rock!". A columnar section is created and edited by entering a single layer's thickness and grain size. **(2)** Musification from the Middle Pleistocene tidal deposits. A columnar section on the left was created on Sedimentary Rock!, and another was modified from Kitazawa and Tateishi (2005).

5 Musification of geological history

A case study of musification from a columnar section of tidal deposits was done (Fig. 1b). The geological strata data was collected from the Middle Pleistocene Ba Mieu and Thu Duc Formations in southern Vietnam (Kitazawa et al., 2006). The Ba Mieu Formation on this outcrop is a tide-dominated delta succession of the paleo Dong Nai River during the highstand of MIS 5 (Kitazawa, 2007), indicating stacks of two tidal sand bars and being buried by muddy tidal flat deposits (Kitazawa and Tateishi, 2005). The music converted from the tidal sand bar deposits is a cyclic melody indicating upward-fining successions due to frequent depositional cycles of development and migration of tidal sand bars. The delta progradation resulted in the shallowing, weakening of tidal current, and deposition of the fine mud in the mud flat. The longer and larger environmental change is converted to a gradually higher tone in the music.

The mud flat deposits are unconformably overlain by mixed flat deposits of the Thu Duc Formation, and the unconformity is amalgamated with a wave/tidal ravinement surface (W/TRS) that is typical in the seaward part of the paleo Dong Nai estuary during a transgression of MIS 5 (Kitazawa, 2007; Kitazawa and Murakoshi, 2016). Thus, there is a remarkable erosion and a loss of previously formed records between the Ba Mieu and Thu Duc Formations. The drastic change in geological history is converted into an abrupt melody change.

6 Educational effects

We surveyed the educational effects of Sedimentary Rock! with some questionnaires. The 29 answers included 21 university students who started to study geology, and 3 of them were learning in a science teacher licensee course, a science teacher, 2 educators in museums, and 5 others. They used Sedimentary Rock!, made a columnar section, listened to several examples of musification from schematic columnar sections of typical depositional environments, and then answered four questionnaires on a 1-5 scale (Table 1). Most answers agreed on the educational effect of using Sedimentary Rock! to understand strata. Those results indicate Sedimentary Rock! has a certain educational effect.

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Table 1. Questionnaire about the educational effects of Sedimentary Rock! (n=29)

Questionary	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
Working to make a columnar section deepens your understanding that the strata consist of concepts of grain size and thickness of the stratum.	76	21	3	0	0
The melody of the music deepens your understanding that the stacks of strata represent the geological history.	41	34	10	14	0
Changes in the melody deepen your understanding that grain size and thickness changes indicate environmental changes.	48	31	10	10	0
Adding hearing and rhythmic senses, as well as visual senses such as outcrop pictures or columnar sections, is useful to understand strata.	45	41	7	7	0

7 Conclusions

Sedimentary Rock! is a new tool that converts columnar sections into human hearing and rhythmic senses. It is easy for anyone to use, and educators can make learners understand that the strata consist of concepts of grain size and thickness of the stratum by working to make a columnar section. Furthermore, the learners understand that the stacks of strata represent the geological history, and the changes in grain size and thickness indicate the environmental changes not only with visual senses such as outcrop pictures or columnar sections but also in hearing and rhythmic senses. Sedimentary Rock! provides a new intuitive experience to listen to the music of geological history.

Supplement link. The web app “Sedimentary Rock!” is available at: http://rissho-es.jp/kitazawa/SedimentaryRock/
The code is available at: https://github.com/kazu404/SedimentaryRock.git

Author contribution. All authors contributed to the design of the concepts of the web app “Sedimentary Rock!”. HiroakiY and TakumaK developed the code and created the Sedimentary Rock Data (SRD) format. KazuakiA administers the web app. ToshiyukiK collected and interpreted geological data. ToshiyukiK prepared the manuscript with contributions from all co-authors.

Competing interests. The authors declare that they have no conflict of interest.

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Ethical statement. The questionnaires in this article have been reviewed by the Ethics Committee, Institute of Environmental Science, Rissho University, and cleared of ethical problems.

Disclaimer. This article was written and published on volunteered time by the authors.

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