# Growth process of buckling folds with polymodal mode

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Buckling folds is an ubiquitous texture formed by large finite deformation , and is commonly observed in metamorphic and sedimentary rocks.. It is shown theoretically and experimentally that when a layer with different lithology and/or material properties from enclosing medium (i.e., matrix) is compressed in a direction parallel to the layer, a waveform with a single wavelength grows, where the wavelength is determined by viscosity contrast between layer and matrix. On the other hand, a polymodal mode which includes several wavelength component is observed in natural folding samples from Sambagawa metamorphic belt, southwest Japan. Existing theory cannot explain these folding mode.

Sambagawa belt, southwest Japan, is a high P/T metamorphic belt related to subduction, but the details of its formation processes remain largely controversial due to its complicated geological structures. Because these folding patterns may include information concerning deformation history, it is very important to clarify the origin .

In this study, we examine formation processes of folding patterns by computer simulation using a finite element method. The purpose is to clarify the origin of polymodal mode observed in natural samples and investigate what kind of information regarding deformation can be extracted from natural samples, i.e., the geometry of foldings

The computer simulation of buckling fold in this study has revealed the major factors that cause polymodal folding: (1) extreme deformation, (2) initial waveform, (3) change of effective viscosity, and (4) stratigraphical structures of layer and matrix. When a folding system is deformed extremely, the growth of normal type of buckling fold reaches the critical state, and behaves a like folding system with thicker layer, to be folded with a longer wavelength, resulting in a complicated fold with two dominant wavelengths (i.e., polymodal mode). When the initial waveform spectra includes a long wavelength component, the initial mode grows simultaneously with the viscosity-controlled mode, and polymodal mode is formed. When viscosity contrast changes with time, especially in case of rapidly increase, polymodal mode is formed, in which the wavelength reflects viscosity contrast between the layer and the matrix at each stage. Multiplelayer system, which is frequently observed in nature, undergoes folding as if it was a single thick layer, and grows with a longer wavelength than that expected from thickness of each layer. Therefore, waveforms with different scales can grow simultaneously for some stratigraphical structures. Each mechanism has its own features in developing polymodal folds, thereby can potentially be distinguished from other mechanisms by inspecting the details of the waveform, spectrum, and their relationship to the layering structures (e.g., thickness and spacing). Comparison between the results of computer simulation, and the actual folds found in Sambagawa metamorphic belts has revealed that polymodal mode observed in the multiplelayer samples has indeed developed through ‘multiplelayer mechanism’, in which several neighboring layers behave as a single thick layer, depending on their spacing.

In this study, rocks are assumed to behave according to power-law creep. The results of this simulation shows that wavelength depends on regional stress field, if stress exponent between the layer and the matrix is different. This means that the wavelengths in natural samples can reflect past regional stress field and history. In addition, if the stress field changes with time, polymodal folding is formed originated from change in effective viscosity. Because the dependence on stress field changes according to whether a ratio between stress exponent of each lithofaces is larger than unity, the polymodal wavelength in natural samples with various combinations of stress exponent may reflect deformation history.