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# Development of Malay Deli Songket Motifs Based on Symmetry Groups

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**ABSTRACT**

One of the tribes in North Sumatra Province that has a wide variety of art is the Deli Malays, especially the Songket motifs. Songket is a type of traditional Indonesian weaving that should be preserved to maintain Indonesia's wealth. The motifs in the Malay Deli Songket can be analyzed because of its symmetrical pattern. In this study, the author developed the Malay Deli Songket motif based on the concept of the symmetry group. The motif development was carried out with the Matlab program based on the frieze group pattern and the crystallography group pattern. The Frieze pattern, often called the Frieze Group, is a symmetry group created from one-way translation, forming a linear pattern that repeats one way. The crystallography group has 17 crystallographic patterns formed by a specific transformation from each type of unit lattice. Through the development of motifs, 6 new Songket motifs were obtained based on the Frieze pattern in 11 observed Malay Deli Songket motifs, namely the Moon Orchid motif, the Orchid motif, the *Balong Ayam* motif, the Coffee Flowers motif, the Tobacco Leaves 1 and 2 motifs, the Corn motif, the Paddy motif, the *Tampuk Manggis* motif, the Tobacco motif, and the *Ulam Raja* motif. In 4 previously observed Malay Deli Songket motifs, 11 new Songket motifs were obtained for crystallography patterns: the Deli Tobacco Leaves motif, the Coffee motif, the *Tampuk Gelugor* motif, and the *Undang Kupu-Kupu* motif.

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## A. INTRODUCTION

In the history of weaving in Indonesia, it is known that various kinds of weaving are produced using ornamental motifs from various threads and spread almost throughout Indonesia (Purwanti & Siregar, 2016). Each region making weaving crafts has a different form of the woven motif as a local identity based on the environment, natural conditions, and adjustments to the situation and needs of the wearer. It is a reflection of the variety of slavery that exists in Indonesia. Weaving has also been used as a tourism promotion platform, which can raise the economic value of woven fabrics. This is evident in Sasak woven fabrics from Lombok, which are widely marketed to the public outside the indigenous community. Consequently, they are well-known both nationally and internationally (Martini et al., 2021).

One of the tribes in North Sumatra Province that has much variety in art is the Deli Malays. The Deli Malays are one of the Malay tribes that inhabit the Deli Serdang regency (Irwansyah & Heldiansyah, 2021). The Deli Malays are rich in various Songket motifs. Songket is a type of traditional Indonesian weaving that should be preserved to maintain Indonesia's wealth. The identity of Songket must be maintained for the sake of the inheritance of skills that run the loom

and apply pre-existing motives. These motifs contain symbolic meanings in life and their relationship with the daily living environment (Viatra & Triyanto, 2014).

In accordance with the characteristics of Malay Deli Songket, namely deli tobacco flowers, the selection of motifs on Songket is only allowed to use floral motifs or plants. The motifs of the Malay Deli Songket have developed along with the times. There are several new motifs of *Kenanga*, jasmine, cape and *Empat Pecah* flowers, also tobacco leaf Conan (Panjaitan et al., 2022). The motifs found in other types of woven fabrics, in addition to songket motifs, can be used as a medium for learning mathematics because each motif on woven fabrics uses mathematical concepts, as previously researched by Rahayu et al., (2020) regarding the relationship between mathematical elements in the *Lipa kaet* woven fabric motif.

The motifs in the Malay Deli Songket can be analyzed mathematically because there is a symmetrical pattern. Kartika et al., (2022) analyzed the Malay Batubara and Langkat songket motifs based on the frieze and the crystallographic group. Lines combined into squares have symmetrical properties; right and left, top and bottom have symmetrical sizes (Nataliani et al., 2021). The Deli Malay Songket motif has a pattern that can be seen in one or two directions. The repeated patterns encountered indicate the presence of symmetry patterns (Fran et al., 2017). The symmetry used in this study was field symmetry, which is also called isometry or rigid geometric transformations (Astriandini & Kristanto, 2021). Geometric transformations are the part of geometry that talks about change (Rohani, 2021). In contrast, an isometry is a bijective function that maintains the distance between the fields themselves (Nggumbe et al., 2018).

The analysis can be carried out based on the concept of a symmetry group consisting of a frieze group and a crystallography group. A symmetry group is a set of isometries that forms a group using function composition operations (Rahmawati et al., 2018). Isometry used in symmetry groups is of four types: (1) Translation, which is the shift or transfer of an object from one point to another; (2) Reflection, which is a shift of an object with the nature of the imagery on the mirror; (3) Rotation, is the rotation of an object with a certain central point; and (4) Glide reflection is a reflection that occurs on a line (Ray & Natalin, 2022).

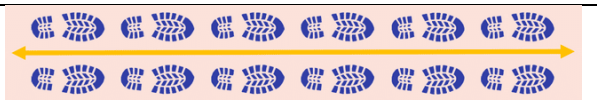
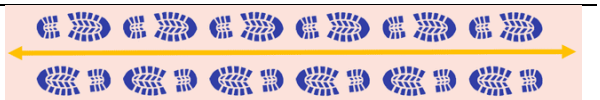
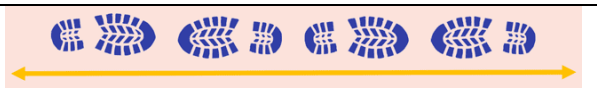
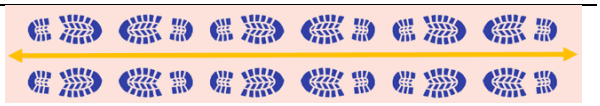
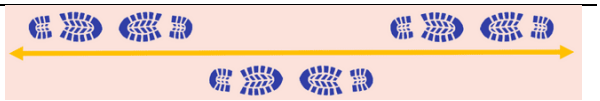
Based on a study of symmetry patterns, Radiusman & Juniati discovered in their research identifying Lombok woven fabrics in 2022 that the inside of the woven fabric motifs is dominated by Wallpaper or Crystallographic patterns, while the edges of the woven fabrics are dominated by Frieze patterns. In the same year, Suwanto et al. found frieze patterns on Ulos from four Batak sub-tribes; namely Uis Karo, Hiou Simalungun, Oles Pakpak, and Ulos Mandailing Angkola. Meanwhile, crystallographic pattern was only found on Uis Karo.

The Frieze pattern, often called the Frieze Group, is a symmetry group created from one-way translation in such a way that it forms a linear pattern that repeats one way, according to Cooper (Rahmawati et al., 2018). If it conjugates G with rotation operations, it obtains a geometrically isomorphic group in the positive x direction (Andriani et al., 2020).

Based on the 1973 Study by Conway and Coxeter, the Frieze pattern consists of 7 types and can be symbolized based on two characters. In the first character, if there is no vertical reflection, it is symbolized by (1), and if there is a vertical reflection, it is symbolized by (m). In the second character, if there is no other isometric, then it is symbolized by (1), if there is a

horizontal reflection, then it is symbolized by (m), and if there is a glide reflection, then it is symbolized by (g). Finally, if there is a half-turn, it is symbolized by (2), as shown in Table 1.

**Table 1.** Frieze Conway Pattern & Coxeter (Silalahi et al., 2022)

| No | Pattern Type | Pattern Image |
|---|---|---|
| 1 | Pattern 11 |  |
| 2 | Pattern 1m |  |
| 3 | Pattern 1g |  |
| 4 | Pattern 12 |  |
| 5 | Pattern m1 |  |
| 6 | Pattern mm |  |
| 7 | Pattern mg |  |

Based on the character Frieze Pattern, the seven types of patterns can be identified as follows: Pattern 11 is only translated in one direction because there is no vertical reflection or another isometry. The 1m pattern undergoes one-way translation. There is no vertical reflection, but there is horizontal reflection. Pattern 1g undergoes one-way translation. There is no vertical reflection, but there is a glide reflection. Pattern 12 undergoes a one-way translation. There is no vertical reflection but a half-turn (180° rotation). Pattern m1 undergoes a one-way translation that contains vertical reflection but no other isometry. Pattern mm undergoes a one-way translation that includes vertical reflection and horizontal reflection. Pattern mg undergoes a one-way translation that includes vertical reflection as well as glide reflection. There is no pattern m2 because it will get the same result as pattern mm.

According to Farmer DW, the wallpaper group, commonly referred to as the crystallography group, is a subgroup of symmetry groups built by two linear non-aligned or free translations (Panamuan & Fran, 2018). The symmetry group on the crystallographic concept consists of 17 groups (Mulyaningsih, 2018). The smallest polygon of each group is called the unit lattice (Garnadi et al., 2012). A unit lattice is said to have an n-order if it has the highest n-folding rotation center (Garnadi et al., 2018). The five types of unit lattices in the Crystallography Pattern are square, parallelogram, rhombus, parallelogram, and hexagonal lattice (Liu & Collins, 1998). According to Schattschneider, 17 pattern crystallographic groups form from each type of unit lattice through the help of a specific transformation, as shown in Figure 1.

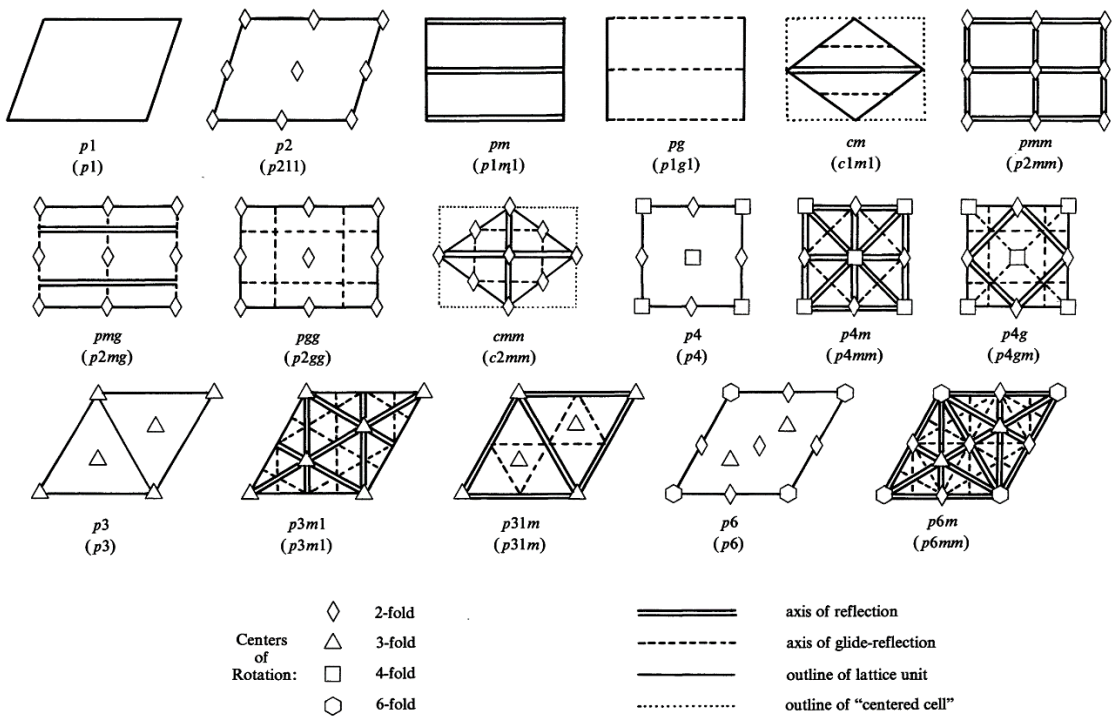



**Figure 1.** 2 Dimensional Crystallographic Pattern (Schattschneider, 2018)

Gallian provides a flowchart for crystallographic pattern identification as in the following figure. The diagram can determine the crystallography pattern in the Malay Deli Songket, as shown in Figure 2.

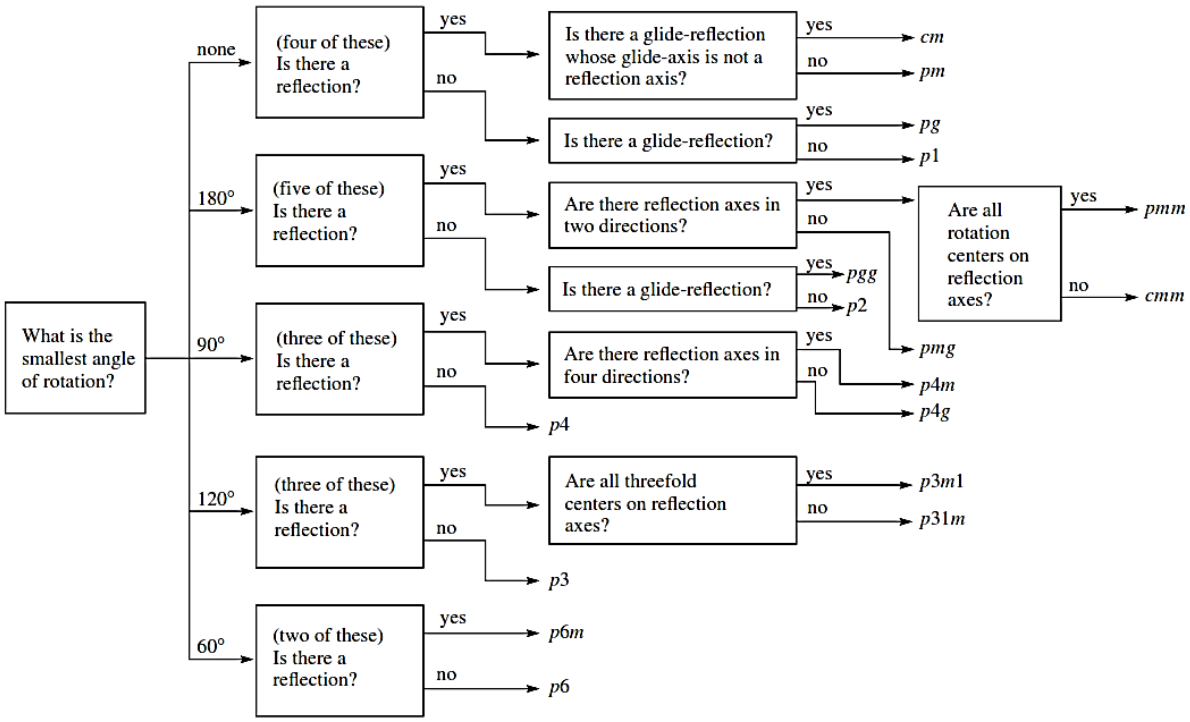



**Figure 2.** Crystallographic Pattern Identification Flowchart (Gallian, 2021)

In making Songket, the motivation for weaving today is not only an expression of art but tends to be oriented towards the market (Viatra & Triyanto, 2014). Although Malay Deli Songket was originally the dress of Malay sultans and nobles and was used on official royal

occasions, the use of Malay Deli Songket became more familiar among the public during various party events.

Due to this dynamic cultural movement, Songket artisans need a variety of new inspirations to create a more diverse Malay Deli Songket motif. Therefore, based on previous research by Panjaitan et al., who have analyzed the ethnomathematics study of the Malay Deli Songket motif pattern based on the symmetry group, the researcher wants to develop the existing basic Pattern to obtain more varied patterns by using the Matlab application. Therefore, a symmetry group algorithm based on seven patterns of the frieze group and 17 patterns of crystallographic groups is used to identify the basic Pattern to form a new pattern suitable for the Songket fabric motif. This research is expected to help artisans and companies engaged in Songket weaving crafts to find new patterns that are more diverse.

## B. METHODS

This study used the concept of symmetry groups to identify and group the Deli Malay Songket pattern. The research methods included developing the analysis of Deli Malay Songket motifs identified based on the Frieze and Crystallography groups using the Matlab application. The development of Malay Deli songket motifs refers to IR & IR Deli Malay songket with the following research stages.

### 1. Determining the Malay Deli songket motif to be developed.

The symmetry group is used to select Deli Malay songket motifs that will be developed into several new songket motifs. The selected Deli Malay songket motif includes 15 different types of songket, referring to IR & IR Deli Malay Songket, as shown in Figure 3.

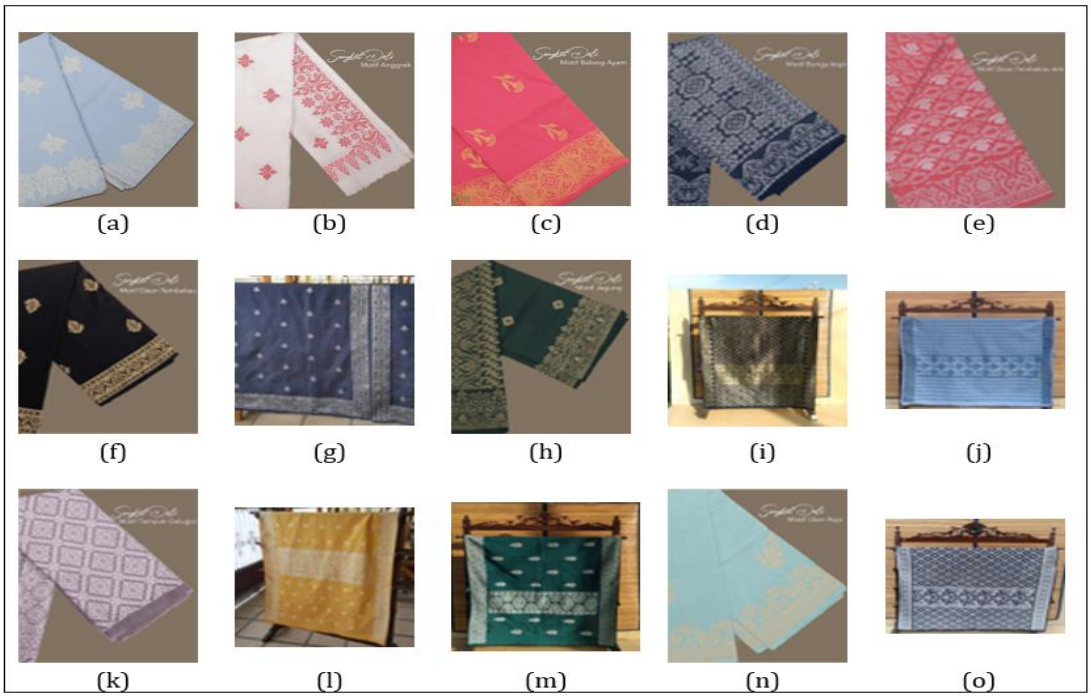



**Figure 3.** Some Malay Deli Songket Motifs, (a) Moon Orchid; (b) Orchid; (c) *Balong Ayam*; (d) Coffee Flower; (e) Deli Tobacco Leaves; (f) Tobacco Leaves 1; (g) Tobacco Leaves 2; (h) Corn; (i) Coffee; (j) Paddy; (k) *Tampuk Gelugor*; (l) *Tampuk Manggis*; (m) Tabaccco; (n) *Ulam Raja*; (o) *Undang Kupu-Kupu*

**2. Taking the basic pattern to be analyzed based on the Frieze group and the Crystallography group.**

The basic pattern of Malay Deli songket is determined at this stage, which will be developed to produce various types of motifs. The basic pattern was determined using the analysis of the Frieze pattern and the Crystallographic pattern of the Deli Malay songket motif conducted by Panjaitan et al., in 2022. According to the findings, 11 of the 15 Deli Malay songket motifs (Moon Orchid motif, Orchid motif, *Balong Ayam* motif, Coffee Flowers motif, Tabacco Leaves 1 and 2 motif, Corn motif, Paddy motif, *Tampuk Manggis* motif, Tabacco motif dan *Ulam Raja* motif) contained the Frieze group pattern, with four others containing crystallographic group patterns (Deli Tabacco Leaves motif, Coffee motif, *Tampuk Gelugor* motif dan *Undang Kupu-Kupu* motif).

3. **Designing source code for MATLAB applications**

The basic pattern of the Malay Deli songket motif that has been determined in stage 2 will be included in the source code design that has been programmed using the MATLAB application. In addition, buttons are inserted to generate new motifs based on Frieze and Crystallographic patterns.

**4. Generating predetermined base patterns based on Frieze patterns and Crystallographic patterns.**

It is important at this stage to convert basic patterns into new motifs based on Frieze groups and Crystallographic groups, after designing programs in the MATLAB application. The pattern of the resulting new motif will be re-analyzed so that it can become a different motif. Figure 4 illustrates the research method used. Following an exploratory study of the basic patterns of Deli Malay songket motifs, the patterns classified based on 7 Frieze patterns and 17 crystallographic patterns (only 11 crystallographic patterns were used in this study) will be made. Because the program is written in MATLAB application, it will generate new, more diverse motifs after being applied to Frieze patterns and other Crystallographic patterns, as shown in Figure 4.

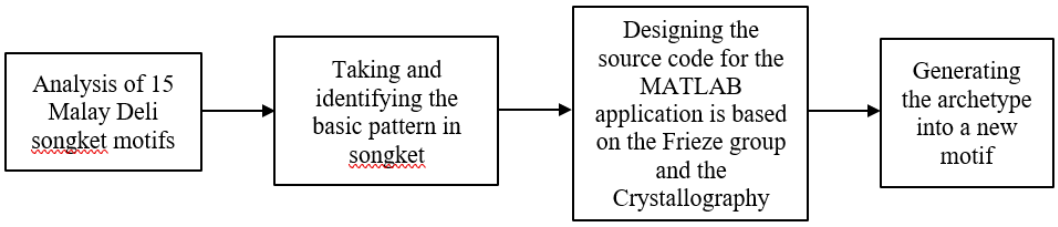



**Figure 4.** Research Methods

## C. RESULT AND DISCUSSION

The basic Pattern of the Deli Malay Songket motif that has been analyzed in previous studies was developed into various new motifs with the classification of frieze groups and existing crystallography groups. The Matlab application, programmed to form a new motif from the basic Pattern of the Malay Deli Songket motif based on the symmetry group pattern, is described for each motif as follows. As an example, the following is the source code

programmed for Malay Deli songket with the Moon Orchid motif with the basic pattern included in the Frieze pattern, as shown in Figure 5.

```
% --- Executes on button press in pushbutton28.
function pushbutton28_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton28 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
cla(handles.axes1);
cla(handles.axes2);
guidata(hObject,handles);
handles.kain = imread('Songket Melayu Deli Anggrek Bulan Motif.jpg');
axes(handles.axes1);
imshow(handles.kain);
handles.pola_dasar= imread('Songket Melayu Deli Anggrek Bulan Pola Dasar.jpg');
axes(handles.axes2);
imshow(handles.pola_dasar);
global IMG
IMG=handles.pola_dasar;
```

**Figure 5.** MATLAB Source Code of Moon Orchid Frieze Pattern

## 1. Moon Orchid Motif

In previous studies, after analysis of the basic pattern of the Moon Orchid motif, one-way translation, and vertical reflection were found, which is pattern m1 in the Frieze group (Panjaitan et al., 2022). When developing Moon Orchid motif by making it into the shape of 6 other Frieze patterns, new, more diverse motifs are produced as shown in Figure 6. Pattern 11 is a new motif created by applying a one-way translation to the basic pattern. When a one-way translation is combined with a horizontal reflection, it results in a new motif, as in the 1m pattern. When a one-way translation is combined with a glide reflection, it results in a new motif, as shown in pattern 1g. When a one-way translation is performed and then rotated 180°, it results in a new motif, as shown in pattern 12. The new motif created by applying the mm pattern has a one-way translation with vertical and horizontal reflections. Meanwhile, the new motif on the mg pattern is created by translating the basic pattern in one direction and then applying vertical reflection and glide reflection, as shown in Figure 6.

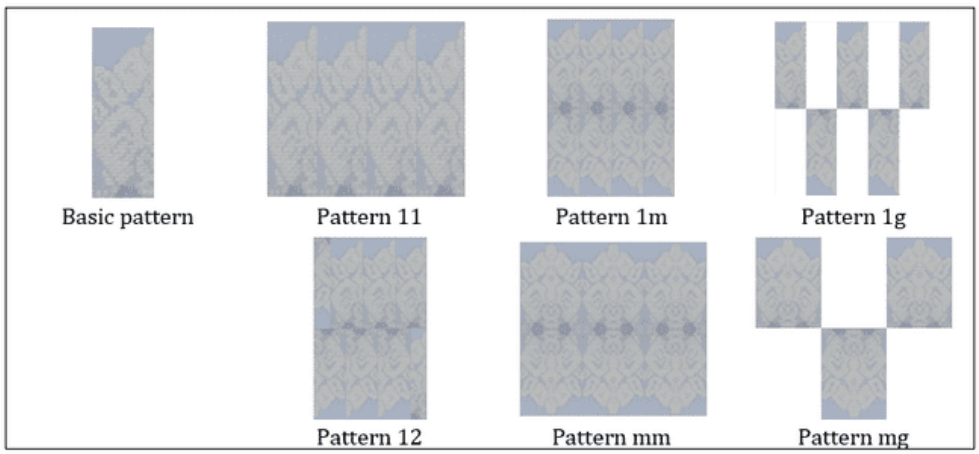



**Figure 6.** Frieze Pattern of Moon Orchid Motif

## 2. Orchid Motif

Songket Melayu Deli Orchid motif has a pattern m1 because there was a one-way translation and only vertical reflection but no horizontal reflection (Panjaitan et al., 2022). Figure 7 illustrates the various new motifs created by combining the Malay Deli songket basic pattern, the Orchids motif, with the other 6 Frieze patterns. Pattern 11 is a new motif produced by applying a one-way translation to the basic pattern. When a one-way translation is combined with a horizontal reflection, it results in a new motif, similar to the 1m pattern. When a one-way translation is combined with a glide reflection, it results in a new motif, as shown in pattern 1g. When a one-way translation is performed and then a half-turn is applied, a new motif is produced, as shown in pattern 12. When the mm pattern is applied, a new motif is created that is a one-way translation with vertical and horizontal reflections. Meanwhile, the new motif on the mg pattern is generated by translating the basic pattern in one direction and then applying vertical reflection and glide reflection, as shown in Figure 7.

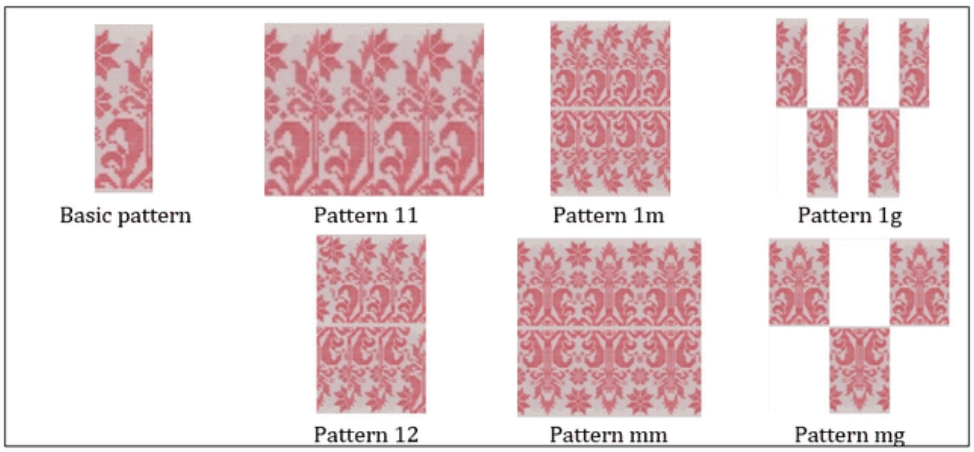



**Figure 7.** Frieze Pattern of Orchid Motif

## 3. *Balong Ayam Motif*

Researchers took the basic pattern from the *Balong Ayam* motif. After analysis, there was only a vertical reflection but no horizontal reflection. Therefore, based on the frieze group concept, the *Balong Ayam* motif was classified as pattern m1 (Panjaitan et al., 2022). Furthermore, when the songket basic pattern is applied to six other Frieze patterns, new motifs are formed, as shown in Figure 8. Pattern 11 is a new motif created by applying a one-way translation to the basic pattern. When a one-way translation is combined with a horizontal reflection, it results in a new motif, as in the 1m pattern. When a one-way translation is combined with a glide reflection, it results in a new motif, as shown in pattern 1g. When a one-way translation is performed and then rotated 180°, it results in a new motif, as shown in pattern 12. The new motif generated by applying the mm pattern has a one-way translation with vertical and horizontal reflections. Meanwhile, the new motif on the mg pattern is generated by translating the basic pattern in one direction and then applying vertical reflection and glide reflection, as shown in Figure 8.

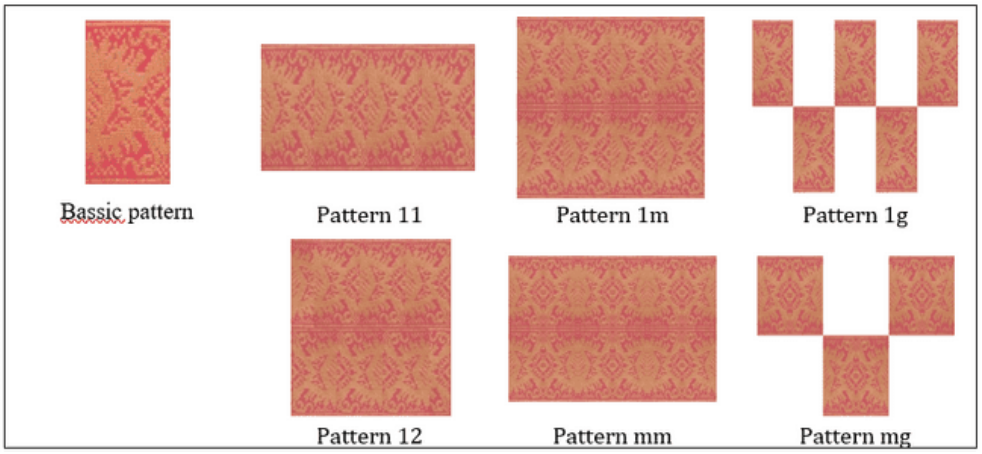



**Figure 8.** Frieze Pattern of *Balong Ayam* Motif

## 4. Coffee Flowers Motif

The Coffee Flowers motif occurred in one direction and has a vertical reflection. However, there was no other isometric, so it can be categorized as pattern m1 in the Frieze group (Panjaitan et al., 2022). It will then be applied to the six patterns in the other Frieze groups depicted in Figure 9. Pattern 11 is a new motif created by applying a one-way translation to the basic pattern of the Coffee Flower motif. When a one-way translation is combined with a horizontal reflection, it results in a new motif, as in the 1m pattern. When a one-way translation is combined with a glide reflection, it results in a new motif, as shown in pattern 1g. When a one-way translation is performed and then a half-turn is applied, a new motif is produced, as shown in pattern 12. When the mm pattern is applied, a new motif is generated that is a one-way translation with vertical and horizontal reflections. Meanwhile, the new motif on the mg pattern is generated by translating the basic pattern in one direction and then applying vertical reflection and glide reflection, as shown in Figure 9.

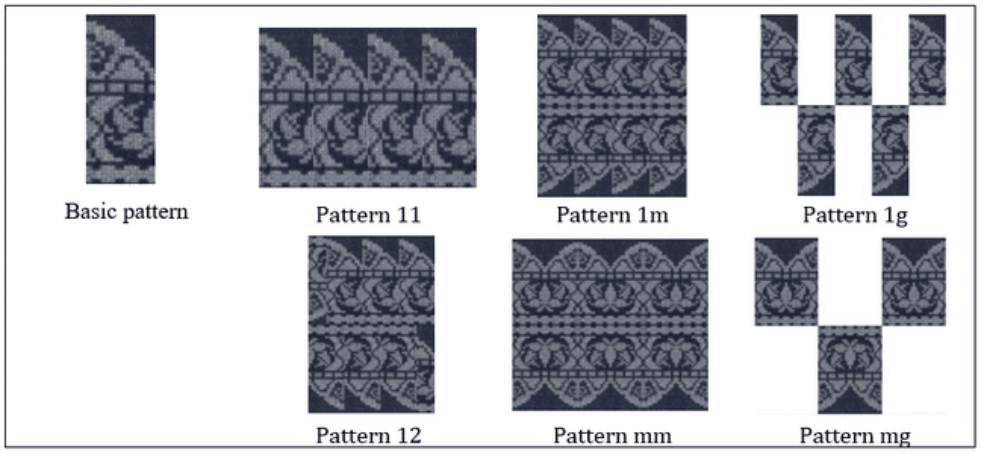



**Figure 9.** Frieze Pattern of Coffee Flowers Motif

## 5. Deli Tobacco Leaves Motif

After the analysis was carried out on the basic pattern of the Deli Tobacco Leaves motif, it was included in the pattern p1 in the Crystallography group because no rotation was found. There was no sliding reflection (Panjaitan et al., 2022). Figure 10 illustrates the process of developing this motif by transforming it into the shape of 11 other Frieze patterns. When the

basic pattern of Deli Tobacco Leaves does not undergo rotation and then reflection and glide reflection are applied, new motifs will form as in the cm pattern, but if glide reflection is not added it will form new motifs such as the pm pattern. The basic pattern that does not experience reflection but has glide reflection is shown in the pg pattern, and the basic pattern that does not experience reflection or glide reflection can be seen in the p1 pattern like the original Deli Tobacco Leaves motif. When a 180° rotation is applied to the pmm pattern, it produces a new pattern with all of the centers of rotation on the reflection axis. When the cmm pattern is rotated 180°, a new motif appears, but not all of the rotation centers are on the reflection axis. The pmg pattern shows new motifs when applied to 180° rotation and reflection but not with bidirectional axes. The use of 180° rotation is also demonstrated in the pgg pattern, which has glide reflection but no reflection. Meanwhile, the motif resulting from the application of 180° rotation without reflection and without glide reflection is shown in pattern p2. The p4g pattern shows a new motif that is generated when the basic pattern is rotated by 90° with shear reflection but not with the four-way reflection axis. Meanwhile, the basic pattern which is rotated 90° without any shear reflection produces new motifs as shown in pattern p4, as shown in Figure 10.

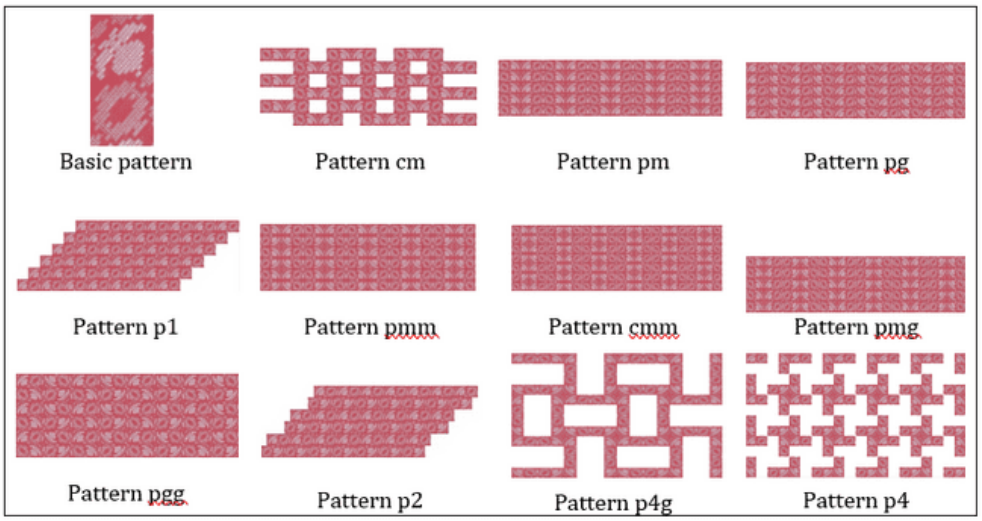



**Figure 10.** Crystallography Pattern of Deli Tobacco Leaves Motif

## 6. Tobacco Leaves 1 Motif

The figure below is the result of developing the basic pattern of the Tobacco Leaves 1 motif, which was applied to other frieze patterns. The Tobacco Leaves 1 motif was essentially a one-way translation with vertical reflection. So the Frieze pattern found is pattern m1 (Panjaitan et al., 2022). When the Tobacco Leaves 1 motif is developed by transforming it into the other six Frieze pattern shapes, new, more diverse motifs are generated, as shown in Figure 11. Pattern 11 is a new motif generated by applying a one-way translation to the basic pattern. When a one-way translation is combined with a horizontal reflection, it results in a new motif, as in the 1m pattern. When a one-way translation is combined with a glide reflection, a new motif is generated, as shown in pattern 1g. When a one-way translation is performed and then rotated 180°, it results in a new motif, as shown in pattern 12. The new motif generated by applying the mm pattern has a one-way translation with vertical and horizontal reflections. Meanwhile, the

new motif on the mg pattern is generated by translating the basic pattern in one direction and then applying vertical reflection and glide reflection, as shown in Figure 11.

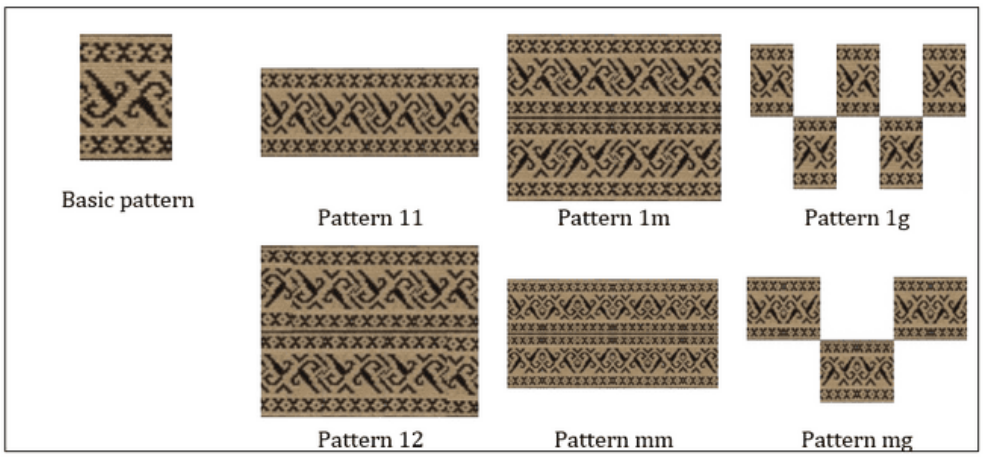



**Figure 11.** Frieze Pattern of Tobacco Leaves 1 Motif

## 7. Tobacco Leaves 2 Motif

The Tobacco Leaves 2 motif has vertical reflection and horizontal reflection. So it can be categorized as pattern mm on symmetry groups (Panjaitan et al., 2022). So that the application to the other 6 Frieze patterns will produce new motifs as shown in Figure 12 below. Pattern 11 is a new motif created by applying a one-way translation to the basic pattern. When a one-way translation is combined with a horizontal reflection, it results in a new motif, as in the 1m pattern. When a one-way translation is combined with a glide reflection, it results in a new motif, as shown in pattern 1g. When a one-way translation is performed and then a half-turn is applied, a new motif is produced, as shown in pattern 12. When the m1 pattern is applied to a new motif, it experiences one-way translation with vertical reflection. Meanwhile, the new motif on the mg pattern is generated by translating the basic pattern in one direction and then applying vertical reflection and glide reflection, as shown in Figure 12.

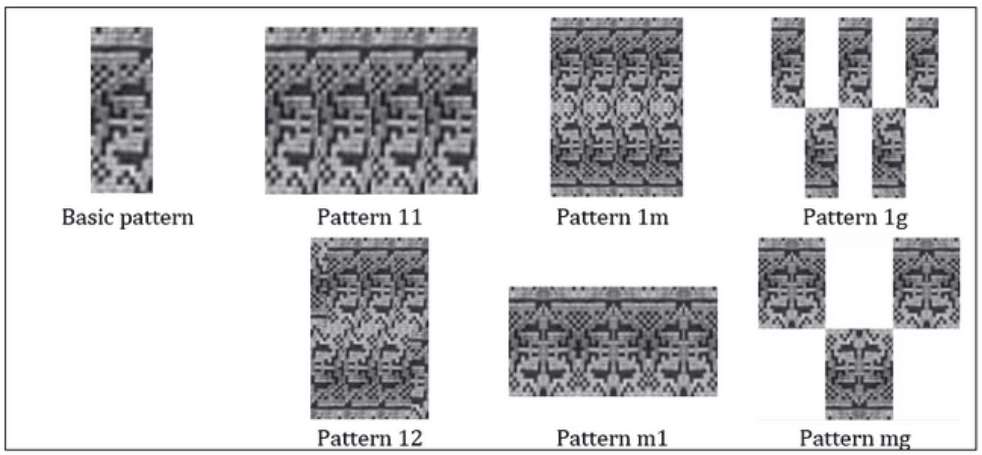



**Figure 12.** Frieze Pattern Motif Tobacco Leaves 2

## 8. Corn Motif

In the pattern corn motif, there was a one-way translation that contained only vertical reflection. There was no horizontal reflection or rotation 180° (Panjaitan et al., 2022). So, it can be classified into the m1 pattern and will be developed with another Frieze pattern, namely 11, 1m, 1g, 12, mm, and mg, to produce a new motif as displayed in Figure 13 below. Pattern 11 is a new motif produced by applying a one-way translation to the basic pattern. When a one-way translation is combined with a horizontal reflection, it results in a new motif, as in the 1m pattern. When a one-way translation is combined with a glide reflection, it results in a new motif, as shown in pattern 1g. When a one-way translation is performed and then rotated 180°, it results in a new motif, as shown in pattern 12. The new motif generated by applying the mm pattern has a one-way translation with vertical and horizontal reflections. Meanwhile, the new motif on the mg pattern is generated by translating the basic pattern in one direction and then applying vertical reflection and glide reflection, as shown in Figure 13.

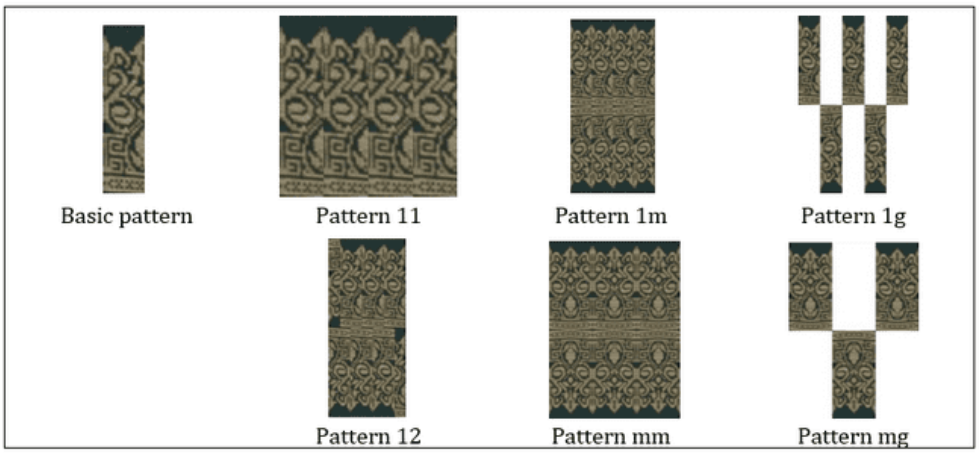



**Figure 13.** Frieze Pattern of Corn Motif

## 9. Coffee Motif

In the previous study, no rotation was found after analyzing the basic pattern of the coffee motif. However, there was a reflection, which was the pm pattern in the Crystallography group (Panjaitan et al., 2022). When this motif is developed by transforming it into 11 other Frieze patterns, new, more diverse motifs are generated, as shown in Figure 14. When the basic pattern of the Kopi (Coffee) motif is not rotated and then reflection and glide reflection are applied, new motifs are formed similar to the cm pattern, but if glide reflection is not added, it forms a pattern similar to the pm pattern. This is the original motif of the Malay Deli Songket Coffee Motif. The basic pattern that does not experience reflection but has glide reflection is shown in the pg pattern, and the basic pattern that does not experience reflection or glide reflection can be seen in the p1 pattern. When a 180° rotation is applied to the pmm pattern, it generates a new pattern with all of the centers of rotation on the reflection axis. When the cmm pattern is rotated 180°, a new motif appears, but not all of the rotation centers are on the reflection axis. When applied to 180° rotation and reflection, the pmg pattern produces new motifs, but not when applied to bidirectional axes. The application of 180° rotation is also shown in the pgg pattern which also has glide reflection without any reflection. Meanwhile, the motif resulting from the application of 180° rotation without reflection and without glide

reflection is shown in pattern p2. When the basic pattern is rotated by 90° with shear reflection but not with the four-way reflection axis, a new motif is generated. Meanwhile, the basic pattern which is rotated 90° without any shear reflection produces new motifs as shown in pattern p4, as shown in Figure 14.

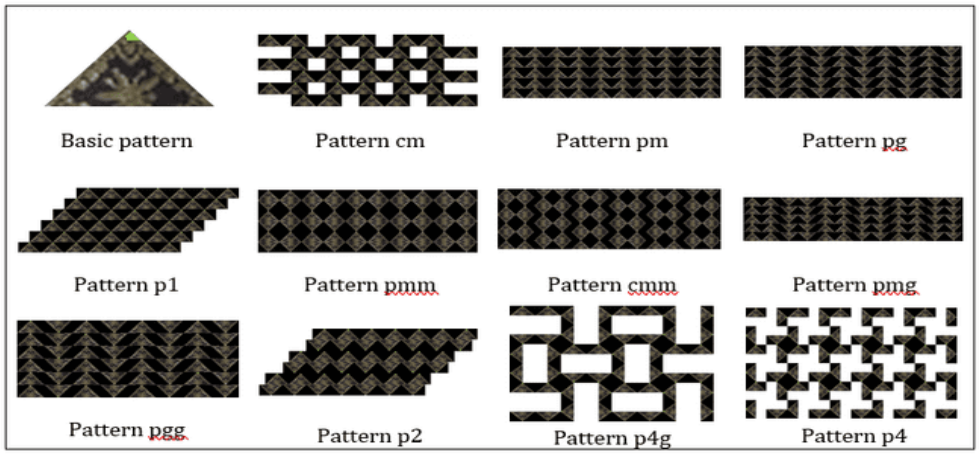



**Figure 14.** Crystallography Pattern of Coffee Motif

## 10. Paddy Motif

The basic pattern of the Paddy motif, a Malay Deli Songket, fictionalizes the symmetrical Frieze pattern. When analyzed, the pattern occurred in one-way translation and only vertical reflection, there was no other isometric, so it is called pattern m1 (Panjaitan et al., 2022). The following Figure 15 are various new motifs from the basic pattern of Malay Deli songket Paddy motifs when the other 6 Frieze patterns have been applied. Pattern 11 is a new motif produced by applying a one-way translation to the basic pattern. When a one-way translation is combined with a horizontal reflection, it results in a new motif, as in the 1m pattern. When a one-way translation is combined with a glide reflection, it results in a new motif, as shown in pattern 1g. When a one-way translation is performed and then a half-turn is applied, a new motif is generated, as shown in pattern 12. When the mm pattern is applied, a new motif is generated that is a one-way translation with vertical and horizontal reflections. Meanwhile, the new motif on the mg pattern is generated by translating the basic pattern in one direction and then applying vertical reflection and glide reflection, as shown in Figure 15.

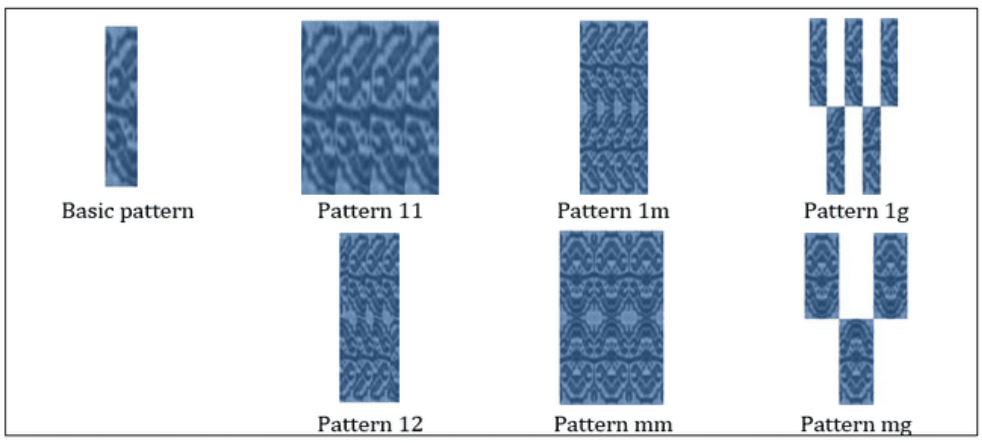



**Figure 15.** Frieze Pattern Paddy Motif

### 11. *Tampuk Gelugor* Motif

In previous studies, after analysis of the basic pattern of the *Tampuk Gelugor* motif, a 90° rotation was found, and there was a four-way reflection, which was the p4m pattern in the Crystallography group (Panjaitan et al., 2022). When this motif is developed by making it into the form of 11 other Frieze patterns, new, more diverse motifs will be produced as shown in Figure 16. When the *Tampuk Gelogor* motif's basic pattern is not rotated and then reflection and glide reflection are applied, new motifs are formed, as in the cm pattern. However, if glide reflection is not added, it will form a pattern similar to the pm pattern. The pg pattern depicts the basic pattern that does not experience reflection but has glide reflection, while the p1 pattern depicts the basic pattern that does not experience reflection or glide reflection. When a 180° rotation is applied to the pmm pattern, it generates a new pattern with all of the centers of rotation on the reflection axis. When the cmm pattern is rotated 180°, a new motif appears, but not all of the rotation centers are on the reflection axis. When applied to 180° rotation and reflection, the pmg pattern produces new motifs, but not when applied to bidirectional axes. The use of 180° rotation is also demonstrated in the pgg pattern, which has glide reflection but no reflection. Meanwhile, pattern p2 depicts the motif generated by applying 180° rotation without reflection and without glide reflection. When the basic pattern is rotated by 90° with shear reflection but not with the four-way reflection axis, a new motif is generated. Meanwhile, pattern p4 shows how the basic pattern, when rotated 90° without any shear reflection, produces new motifs, as shown in Figure 16.

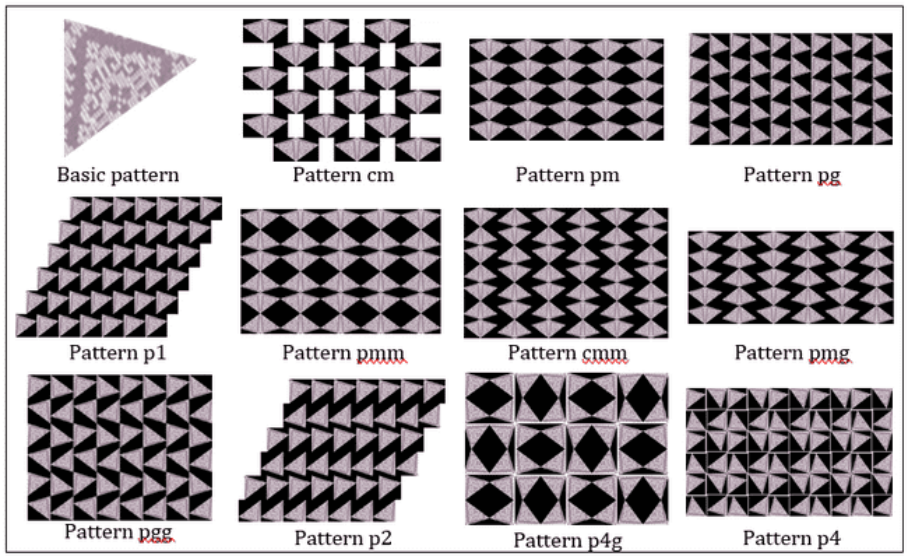



**Figure 16.** Crystallography Pattern of Tampuk Gelugor Motif

### 12. *Tampuk Manggis* Motif

There was a translation in the basic pattern of the *Tampuk Manggis* motif, but it did not have any isometry other than vertical reflection. So, just like other Deli Malay Songket motifs that only experience vertical reflection, the *Tampuk Manggis* motif has a pattern m1 (Panjaitan et al., 2022). When the *Tampuk Manggis* motif was developed by making it into the other 6 Frieze patterns, new and more diverse motifs were produced as shown in Figure 17. Pattern 11 is a new motif that is produced when a one-way translation is applied to the basic pattern. When a one-way translation is performed plus a horizontal reflection, it will produce a new motif as

in the 1m pattern. When a one-way translation is performed plus a glide reflection, it will produce a new motif as in pattern 1g. When a one-way translation is carried out and then rotated 180°, it will produce a new motif as in pattern 12. The new motif that is generated when applying the mm pattern is experiencing a one-way translation where there are vertical reflections and horizontal reflections. Meanwhile, the new motif on the mg pattern is generated when the basic pattern is translated in one direction and then vertical reflection and glide reflection are applied, as shown in Figure 17.

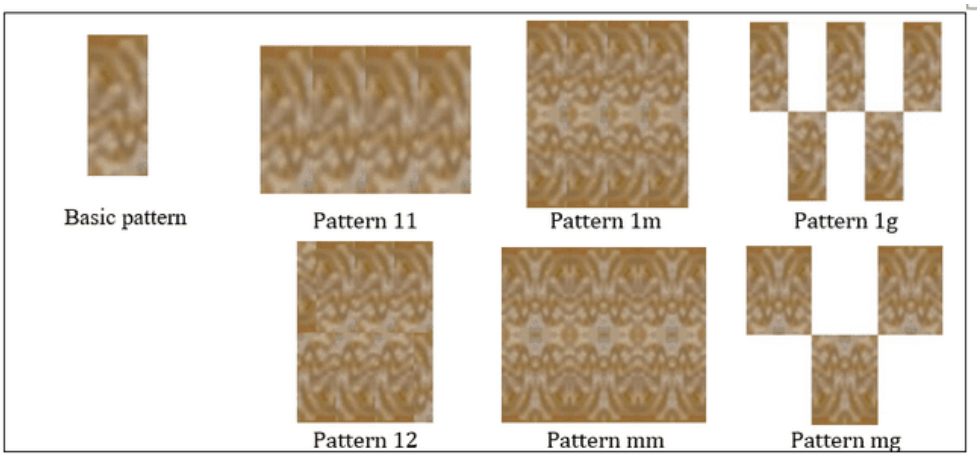



**Figure 17.** Frieze Pattern of *Tampun Manggis* Motif

## 13. Tobacco Motif

The basic pattern on the tobacco motif that has been analyzed shows pattern m1 in the Frieze group because it only occurred as vertical reflection. There was no horizontal reflection or axis of rotation (Panjaitan et al., 2022). However, the basic pattern can form a new motif with the development of other existing patterns. The following figure 18 are the various new motifs from the basic Malay Deli songket pattern of Deli Tembakau (Tobacco) motifs when the other 6 Frieze patterns have been applied. Pattern 11 is a new motif formed by applying a one-way translation to the basic pattern. When a one-way translation is combined with a horizontal reflection, it results in a new motif, as in the 1m pattern. When a one-way translation is combined with a glide reflection, it results in a new motif, as shown in pattern 1g. When a one-way translation is performed and then a half-turn is applied, a new motif is produced, as shown in pattern 12. When the mm pattern is applied, a new motif is created that is a one-way translation with vertical and horizontal reflections. Meanwhile, the new motif on the mg pattern is generated by translating the basic pattern in one direction and then applying vertical reflection and glide reflection, as shown in Figure 18.

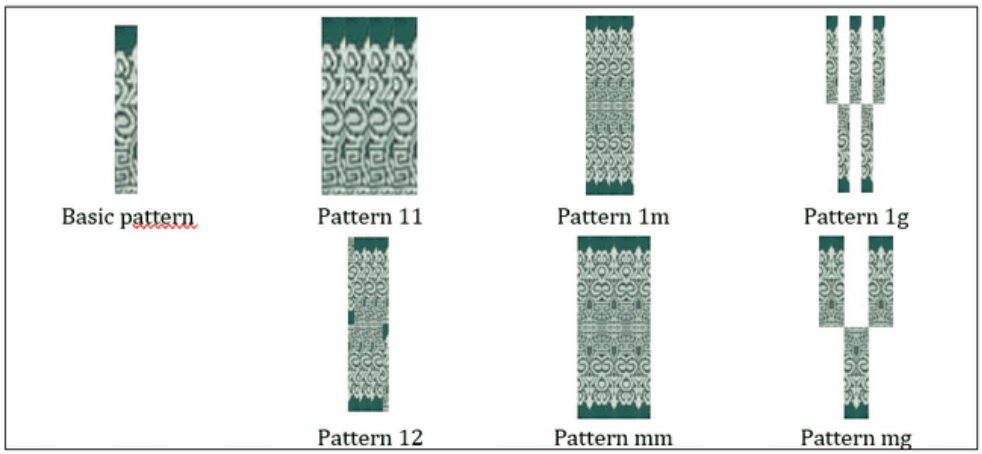



**Figure 18.** Frieze Pattern of Tobbacco Motif

### 14. *Ulam Raja* Motif

The *Ulam Raja* motif, part of the Deli Malay Songket, has a pattern m1 in its symmetry analysis. *Ulam Raja*'s motif occurred in one-way translation with other isometrics without vertical reflections (Panjaitan et al., 2022). The development of the *Ulam Raja* motif on the Frieze pattern in the symmetry group can be seen in Figure 19 below. Pattern 11 is a new motif produced by applying a one-way translation to the basic pattern. When a one-way translation is combined with a horizontal reflection, it results in a new motif, as in the 1m pattern. When a one-way translation is combined with a glide reflection, it results in a new motif, as shown in pattern 1g. When a one-way translation is performed and then rotated 180°, it results in a new motif, as shown in pattern 12. The new motif created by applying the mm pattern has a one-way translation with vertical and horizontal reflections. Meanwhile, the new motif on the mg pattern is generated by translating the basic pattern in one direction and then applying vertical reflection and glide reflection, as shown in Figure 19.

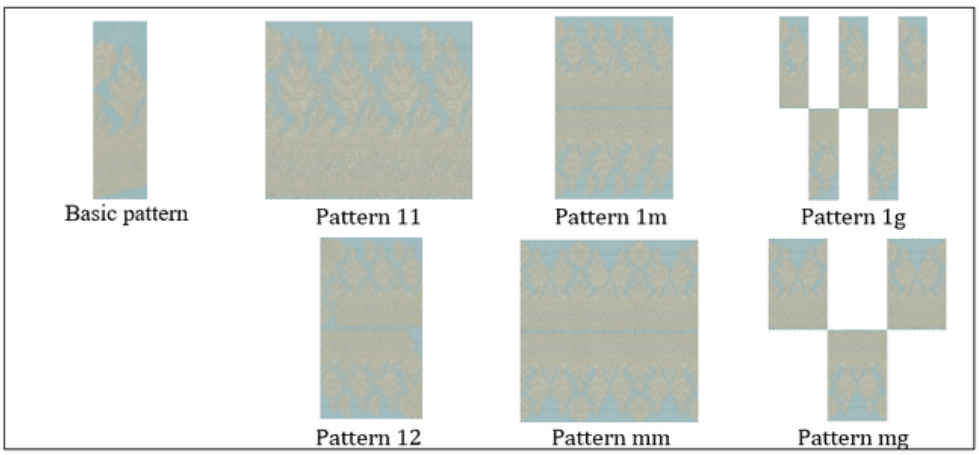



**Figure 19.** Frieze Pattern of *Ulam Raja* Motif

### 15. *Undang Kupu-Kupu* Motif

In the previous study, after an analysis was carried out on the basic pattern of the *Undang Kupu-Kupu* motif, a rotation of 90° was found, and there was a reflection of four directions, which is the p4m pattern in the Crystallography group (Panjaitan et al., 2022). However, when the development of the motif was made into the form of 16 other Frieze patterns, namely cm,

pm, pg, p1, pmm, cmm, pmg, pgg, p2, p4g, and p4, a new and more diverse motif was produced. When the basic pattern of the Tampuk Gelogor motif does not rotate and then reflection and glide reflection are applied, a new motif is formed similar to the cm pattern, but if glide reflection is not added, a pattern similar to the pm pattern is formed. The basic pattern that does not experience reflection but has glide reflection is shown in the pg pattern, and the basic pattern that does not experience reflection or glide reflection can be seen in the p1 pattern. When a 180° rotation is applied to the pmm pattern, it generates a new pattern with all of the centers of rotation on the reflection axis. When the cmm pattern is rotated 180°, a new motif appears, but not all of the rotation centers are on the reflection axis. When applied to 180° rotation and reflection, the pmg pattern produces new motifs, but not when applied to bidirectional axes. The application of 180° rotation is also shown in the pgg pattern which also has glide reflection without any reflection. Meanwhile, pattern p2 depicts the motif generated by applying 180° rotation without reflection and without glide reflection. When the basic pattern is rotated by 90° with shear reflection but not with the four-way reflection axis, a new motif is generated. Meanwhile, pattern p4 shows how the basic pattern, when rotated 90° without any shear reflection, produces new motifs, as shown in Figure 20.

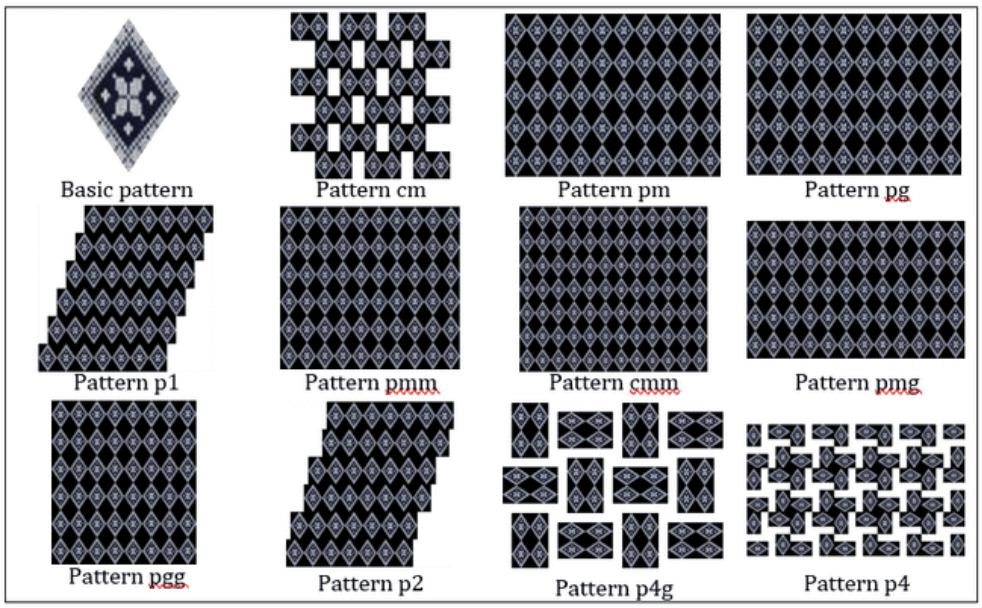



**Figure 20.** Crystallography Pattern of *Undang Kupu-Kupu* Motif

## D. CONCLUSION AND SUGGESTIONS

This study has developed the frieze and crystallography patterns on several Malay Deli Songket fabrics. On each motif of Songket fabric was found a symmetrical pattern. The analysis carried out on the basic pattern pieces of the Malay Deli Songket in finding the pattern of the symmetry group was developed using the Matlab application to obtain new, more diverse motifs. This study obtained six new Songket motifs based on the Frieze Pattern in 11 observed Deli Malay Songket motifs, namely the Moon Orchid motif, Orchid motif, *Balong Ayam* motif, Coffee Flowers motif, Tobacco Leaves 1 and 2 motifs, Corn motif, Paddy motif, *Tampuk Manggis* motif, Tobacco motif, and *Ulam Raja* motif. For crystallography patterns, 11 new Songket motifs were obtained in 4 observed Malay Deli Songket motifs, namely, the Deli Tobacco Leaves motif,

the Coffee motif, the *Tampuk Gelugor* motif, and the *Undang Kupu-Kupu* motif. It is hoped that further research can develop more Malay Deli Songkets so that new motifs are produced that are more diverse even though they use the same basic pattern.

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