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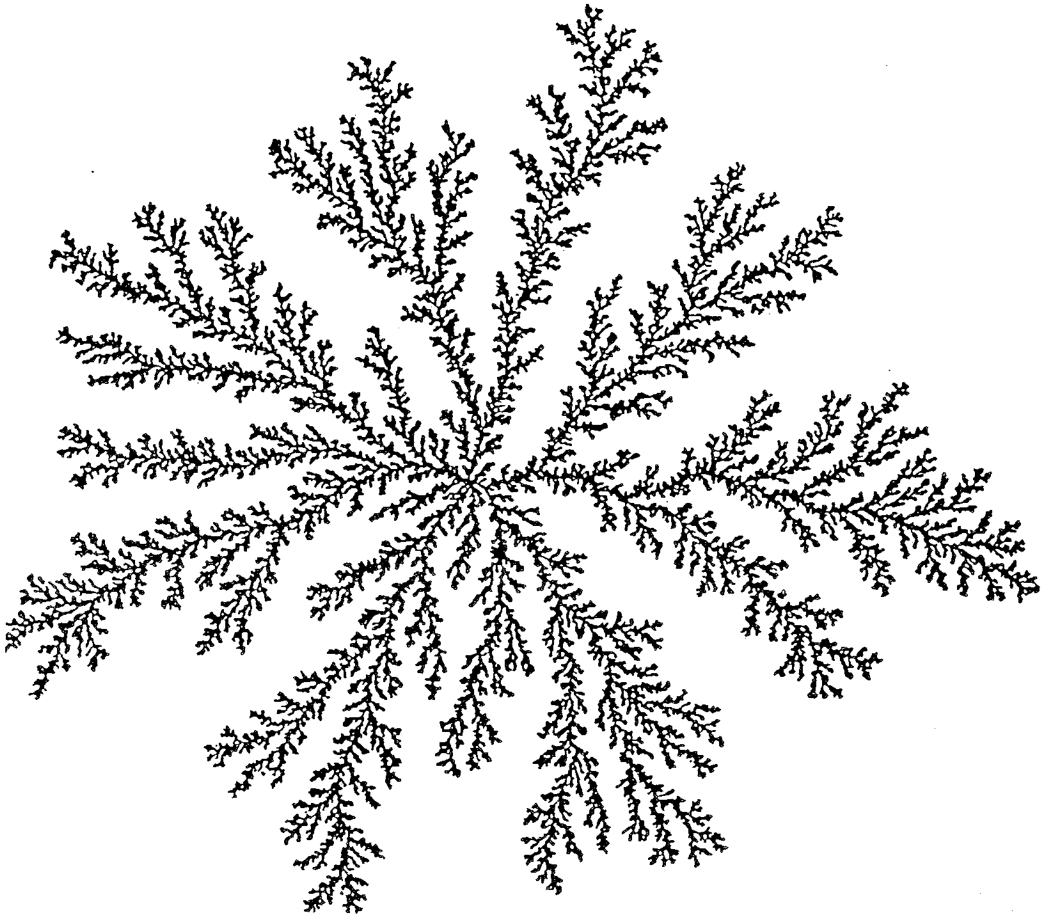

DLA fractal cluster of 10^6 particles

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ADMIRALTY ISLANDS SPEAR DECORATIONS: A MINICATALOG OF pmm PATTERNS

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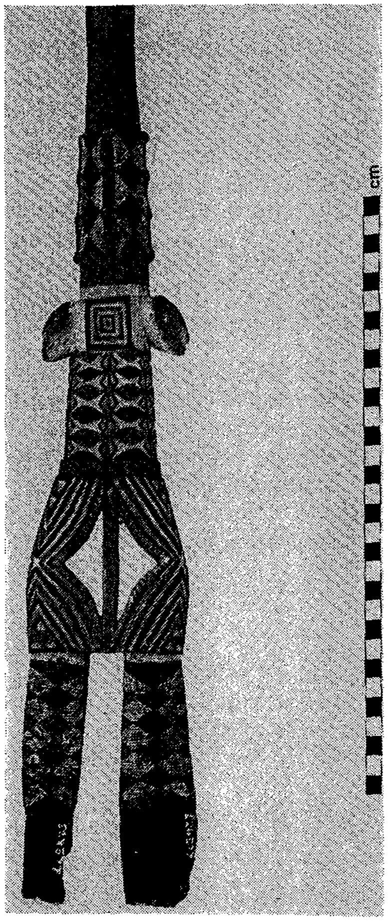

Double-bladed Admiralty Islands spear, from the period 1911-1919, illustrating two-colorings of the pattern pmm in four places: (i) as binding to haft, type pmm/pmm, (ii) as painted decoration on collar adjacent to haft, type pmm/pmm, and (iii) twice as binding of obsidian blades to collar, type pmm/cmm. AM E24577. (Australian Museum photograph.)

1 INTRODUCTION

A study of the decorations used on Admiralty Islands spears and daggers has been carried out as part of a larger study on obsidian trade in Melanesia (e.g., Torrence 1989, 1993). One of the objectives of this work is to analyze the way spear manufacture and decoration has changed during the past 150 years of European contact. Although two different types of spears were manufactured in the Admiralties, we describe here only those for which the blade is attached to the shaft by means of string wrapped around a wooden collar in one or more places. Our aim is to describe the geometric symmetries of the (generally 'two-color') repeated patterns of the bindings which attach the obsidian blade to its mounting, and the mounting to the shaft of the spear. This detailed study is based on the extensive collections housed at the Australian Museum, Sydney, and the Field Museum of Natural History in Chicago, although a wider sample of material was included in the broader study (Torrence 1989, 1993).

2 HISTORY

Admiralty Islands spears were first reported in 1767 by Carteret, captain of the English ship *Swallow*, who reported that these weapons were thrown at the boat during a hostile encounter. Unfortunately the spears were not described and do not appear to have been collected. Spears apparently first entered private collections in England in the 1860's, at a time when bartering with European entrepreneurs for local products normally took place at sea. In 1875 members of the scientific expedition aboard the *HMS Challenger* went ashore on the mainland of Manus island for the first time. Already by this date, the Admiralty Islanders were accustomed to the concepts of trade and profit. In the mere week spent by the *Challenger* in the islands, the expedition's naturalist reported that the local people "soon took to making trade goods, shell hatchets, and models of canoes, e.g., which were as badly made as our own trade gear" (Moseley 1877, p. 142). Around this time a number of traders based in New Britain attempted, with mixed success, to set up permanent posts in the Admiralties.

Until the nineteenth century, artifacts were often procured by traders in this area, because the local people were not interested in producing copra for sale. For example, the Australian Museum acquired a large number of spears (179) from Mr. and Mrs. Farrell who were based in New Britain and were active traders in the Bismarck Archipelago; similarly, the Field Museum purchased a smaller number from their brother-in-law, Parkinson.

The Admiralty Islands were annexed by Germany in 1877 and plantations began to be established by 1900. However, up to 1910 spears were commonly used in local warfare and in hostilities with Europeans. The period 1900-1919 marks a zenith in the trading of spears to Europeans both as a result of increased economic activity by traders and because of visits by a number of large expeditions from major museums. The bulk of the Field Museum's collection (117 spears) was purchased from a Japanese plantation owner by A. B. Lewis on his 1911 visit to the Admiralty Islands. It is also during this period that the most elaborately decorated spears were made for sale.

After World War I, in 1919, the Admiralty Islands were mandated as part of New Guinea to Australia by the League of Nations. From this time artifact sales decreased markedly because the demands of European collectors and museums for primitive artifacts had dwindled and local people turned increasingly to wage labor. When tourist sales were boosted again by the arrival of soldiers during World War II, large spears were no longer being made, having been replaced by small, cheaply produced daggers.

In addition to those of the Australian and Field Museums there are substantial collections of spears in the Pitt Rivers Museum in Oxford and the Museum of Mankind in London; the second author has recorded the museum locations of some 700 spears (Torrence 1989). The authors examined essentially all the spears at the Australian and Field Museums, with the object of classifying the repeated patterns seen in their bindings. Our data, and examples, were obtained from these two sources. Considering the small differences between these two collections, and the fact that they contain a considerable proportion of the available spears, it seems reasonable to suppose that we have seen a very representative sample of the spears that were taken away from the Admiralty Islands by outsiders.

3 GEOMETRIC AND COLOR SYMMETRY

This section contains a brief description of the mathematical context within which the first author approached the Admiralty Islands spear decorations.

For their own purposes 19th Century European crystallographers carried out a systematic classification of all possible types of repeated pattern in space. (From their point of view this was an enumeration of all possible crystal structures. However, this enumeration was a purely mathematical project whose result was a description of all 230 possible discrete repeated patterns in space.) This enumeration was based on the *symmetries* of the pattern, that is the reflections, translations, rotations, and glide-reflections which transform the pattern onto itself. As a byproduct of their work we know that when discrete repeated patterns are classified according to their symmetries there are exactly 7 possible band patterns ('one-dimensional') and 17 possible plane patterns ('two-dimensional').

Although from the purely geometric point of view all these (7 + 17) patterns are infinite in extent, many real-world patterns exhibit sufficiently many repetitions that they can be considered as portions of such infinite patterns. The first author has used this idea in applying the crystallographers' tools to the study of patterns found in various African contexts (Crowe 1971, 1975, 1982). A pattern is often *two-colored,* in the technical sense that it is composed of two identical parts, one of each of two colors conveniently called black and white. By 'identical parts' we mean that some symmetry of the pattern exactly interchanges the two differently colored portions. (In the spear decorations studied here the actual colors are almost always black and red, most often on a white background.) An easy example is an ordinary black-white checkerboard, or more accurately a checkerboard imagined as extending to infinity in all directions. In this checkerboard case, for example, a rotation of the whole board by 90° about a point where four squares meet interchanges the black and white squares throughout. Likewise, a reflection in any line containing an edge of one of the squares exactly interchanges the black and white squares. Such symmetries are called *color-reversing* symmetries.

The color-reversing symmetries, together with the *color-preserving* symmetries (such as 90° rotations around the center of one of the checkerboard squares), are the color symmetries of a two-color pattern. When these *color symmetries* are taken into account the numbers of different two-color patterns increase to 17 band patterns and 46 plane patterns. These color symmetry classifications have been used to study the patterns of San Ildefonso pottery (Crowe and Washburn 1985) as well as the Cakaudrove patterns of Fiji (Crowe and Nagy 1992) and the basketry and rafterlashing patterns of Tonga (Crowe, submitted).

A complete discussion, with many illustrations, suitable for use by non-mathematical readers, is presented in *Symmetries of Culture* (Washburn and Crowe 1988). In that book the 17 + 46 two-color pattern classes are organized according to the underlying pattern of which they are colorings. The essence of the present note is the observation that there are five mathematically possible two-colorings of the pattern 'pmm' and that all five of them are represented in Admiralty Islands spear bindings. The computer-drawn versions of this underlying pmm pattern (Figure 1) and its five two-colorings (Figures 2 to 6), are remarkably similar to the spear bindings shown in the accompanying drawings. However, at the time the computer drawings were made the authors were unaware of the spear decorations.

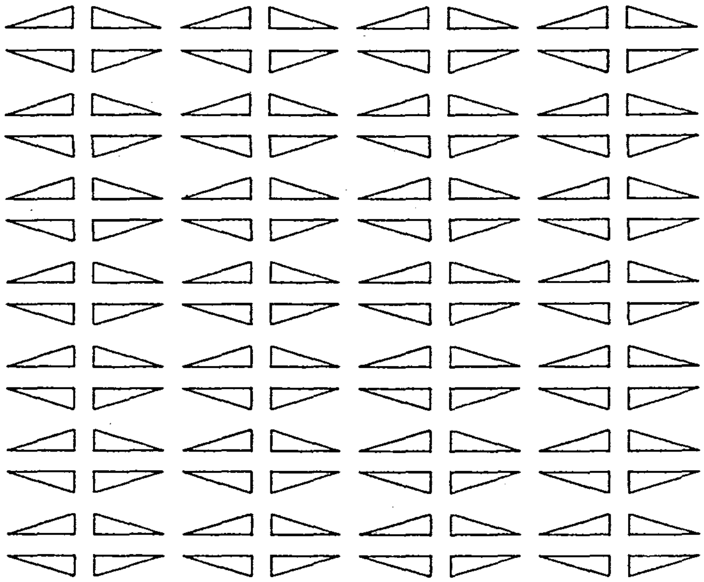

Figure 1: Computer-drawn prototype of underlying pattern pmm.

4 THE FIVE TWO-COLORINGS OF pmm IN ADMIRALTY ISLANDS SPEAR DECORATIONS

The rest of this note deals primarily with the 'catalog' of two-colorings of the pattern pmm (Figure 1) as seen in decorative Admiralty Islands spear bindings. Hence we briefly discuss the geometric characterization of the class of pmm patterns. Although the pattern notation was invented by crystallographers for their own purposes, in this particular case, pmm, the notation has a straightforward commonsense interpretation. The 'p' can be thought of as standing for 'plane' or 'periodic', signifying that this is a two-dimensional (i.e., potentially plane-filling) pattern. The two m's indicate that there are reflections in two directions. That is (referring to Figure 1) there are lines - not drawn in this figure - in two perpendicular directions, with respect to each of which the pattern has bilateral symmetry. In the Figure 1 version of the pmm pattern, half of these lines pass through the centers of the diamond triangle groups, and the other half pass between the diamonds. As a consequence of this there are also half-turns (180° rotations) whose centers are the points where two reflection lines intersect, but since these rotations are mathematical consequences of the existence of the reflection lines these half-turns do not need to be recorded in the pmm notation.

In passing it may be noted that an ordinary rectangular grid has exactly the same symmetries as the pattern of Figure 1 and hence is also of type pmm. In the rectangular grid the lines of the grid are reflection lines, as are lines parallel to those through the centers of the rectangles. The (180°) rotation centers are at the intersections of these lines, at the centers, edge midpoints, and corners of the rectangles of the grid. If the rectangles of the grid are actually squares, as in an ordinary (uncolored) checkerboard, then there are quarter-turns (90°) around the centers of the squares and around their corners. The notation for such a square grid pattern is p4m.

The pmm pattern of Figure 1 (or any other pmm pattern) can be 'two-colored', in the technical sense described above, in exactly five ways, as follows (an explanation of the symbols pmm/pmm, etc. is given in the next paragraph):

(i) Alternate rows (or columns) of diamonds are colored black and the remaining diamonds white. (See Figure 2a.)

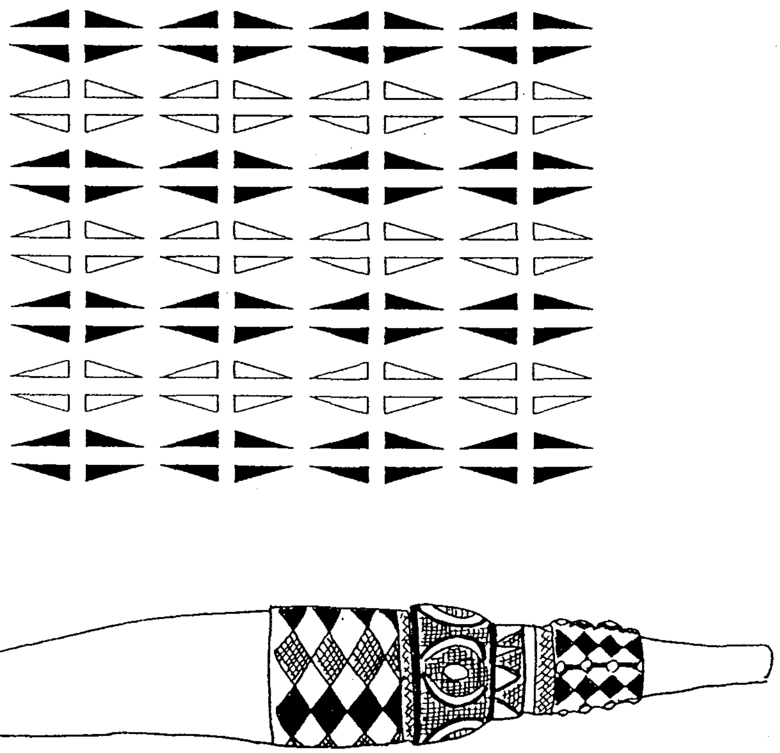

Figure 2: Pattern type pmm/pmm. (a) Computer-drawn prototype.
(b) Admiralty Islands spear binding (blade to midsection). Black-red on white background. (Shaft end illustrates pmm.) AM E30769. (1911-19)

(ii) Diamonds are colored black, or white, in a checkerboard pattern. Thus in any row (or column) of the pattern the diamonds alternate colors. (See Figure 3a.)

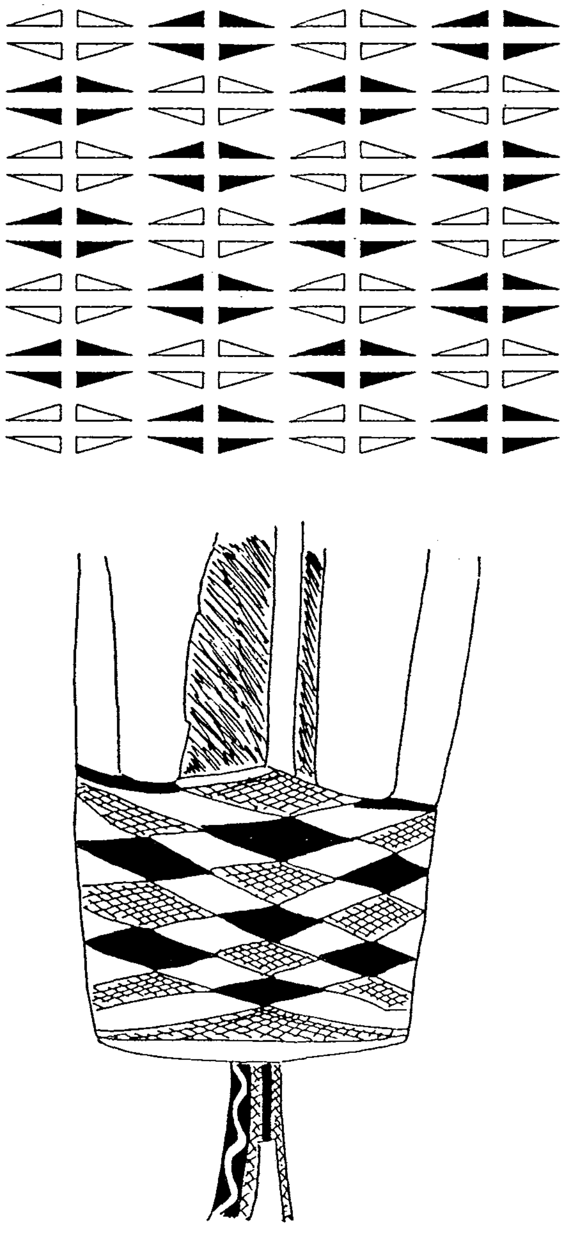

Figure 3: Pattern type pmm/cmm. (a) Computer-drawn prototype. (b) Admiralty Islands spear binding. Unusual blue and red on white background. AM E25859. (1911-19)

(iii) The left (or right) two triangles of each diamond are colored black, while the remaining triangles are white. The same symmetry result is obtained if the upper (or lower) two triangles of each diamond are colored black, leaving the others white. (See Figure 4a.)

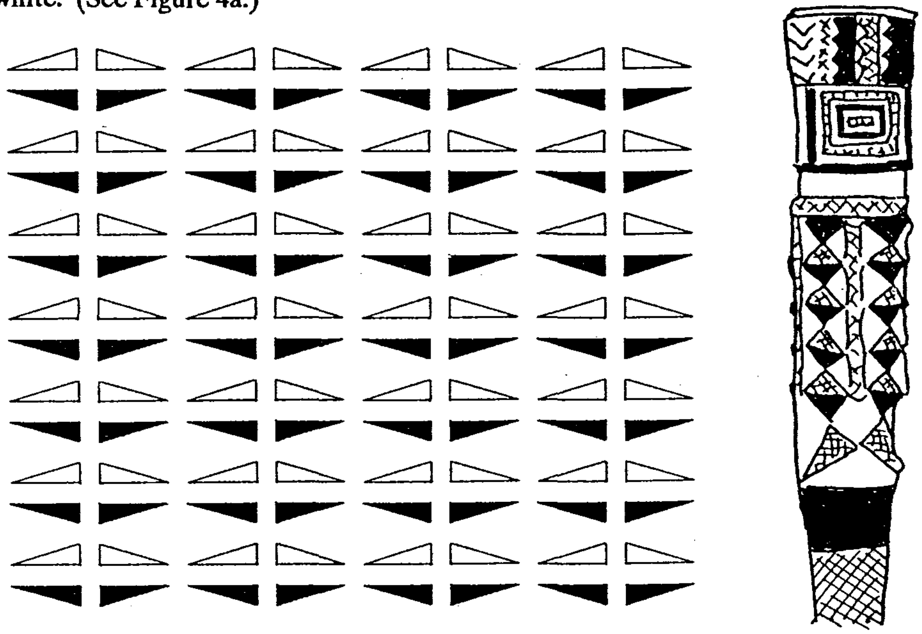

Figure 4: Pattern type pmm/pm. (a) Computer-drawn prototype. (b) Admiralty Islands spear binding (midsection to shaft). Black-red on white background. AM E19180. (1911-19)

(iv) Along each row (or column) of diamonds the top two triangles of alternate diamonds are colored black while the lower two triangles of the remaining diamonds are colored black. All other triangles remain white. (See Figure 5a.)

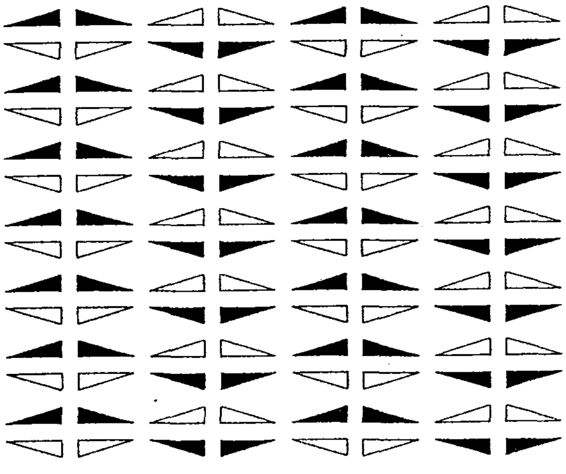

Figure 5: Pattern type pmm/pmg. (a) Computer-drawn prototype.

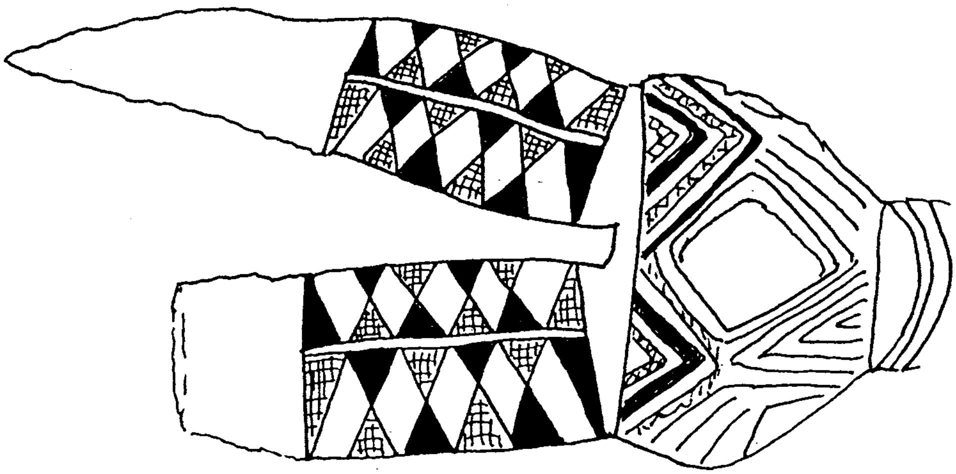

Figure 5: Pattern type pmm/pmg. (b) Admiralty Islands spear binding. Double-bladed spear. Black-red on white background. FM 134342. (1911-19)

(v) The triangles are colored alternately black and white, so that no two adjacent triangles have the same color. (See Figure 6a.)

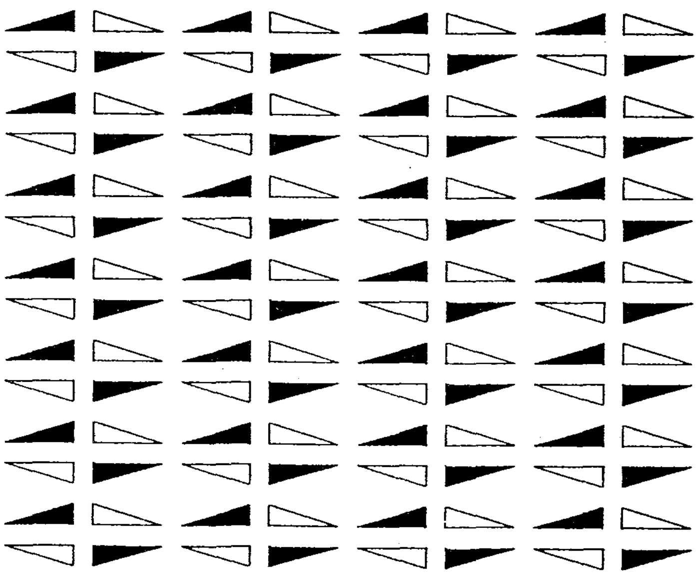

Figure 6: Pattern type pmm/p2. (a) Computer-drawn prototype.

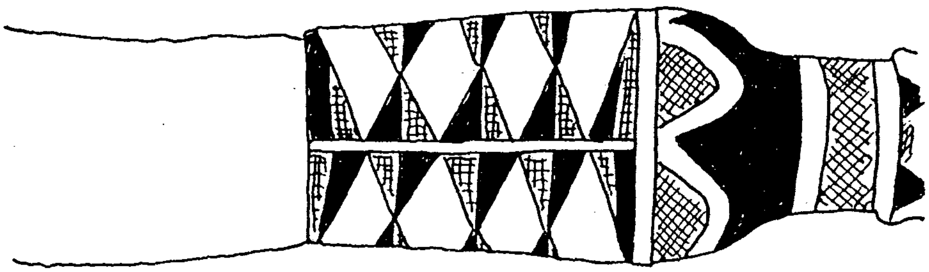

Figure 6: Pattern type pmm/p2. (b) Admiralty Islands spear binding. Black-red on white background. AM E11401. (1876-1910)

A convenient notation, introduced by Coxeter (Coxeter 1986, Washburn and Crowe 1988, p. 72) for two-color patterns, accompanies each of Figures 2 to 6. This notation is of the form T/T', where T is the type of the underlying pattern, and hence is pmm in all these five cases. Then T' is the type of the black portion (or white, since the two are congruent and hence have the same symmetry types) of the pattern. Thus, for the pattern in Figure 2 the notation is pmm/pmm, since the black pattern by itself has the same kind of symmetry as the original uncolored pattern. For the checkerboard coloring of the pattern in Figure 3 the type is pmm/cmm, the cmm being the crystallographic way of indicating that there are still reflections in two perpendicular directions, but that the black diamonds are now arranged in a staggered array. For Figure 4 the notation pmm/pm tells us that the black portion by itself admits reflections in only one direction. In Figure 5 the denominator pmg indicates that for the black portion of the pattern there are reflections ('m') in one direction, but in the perpendicular direction only glide-reflections ('g'). Finally, in Figure 6 the p2 denominator tells us that the black portion admits *no* reflections, but does admit half-turns ('2'), for example around the centers of the diamonds.

Turning now to the drawings of spears accompanying the schematic drawings, one is immediately struck by the resemblance between these drawings and the corresponding computer drawings. Note that the shaft end in Figure 2b represents the pmm pattern of Figure 1. In Figures 2b and 4b-6b the black of the drawing represents black on the binding, while the hatched parts represent red. The background is generally white in the actual spear bindings. In 3b, which is atypical in other ways as well, the binding colors are blue and red on a white background. It seems likely that this spear, with its four sting-ray spines surrounding the obsidian blade, and six rows of diamonds (instead of the usual four) was manufactured specifically to meet the (implicit or explicit) requirements for trade to outsiders. The blue, in particular, is a striking anomaly.

Except for 3b the illustrated spears are typical, in the sense that most other examples of their pattern types look much the same, black and red on a white background. The binding of 6b is the *only* example we saw of its pattern type. It is neatly and carefully crafted, and it is only in pattern type, not color, style or craftsmanship that it differs from the others. For some of the other pattern types there are slight variations in the way the triangles are drawn, or in the coloring. On one example

(FM 134304) the two colors of the binding, which does not otherwise seem exceptional, are black and white on a red background.

Many spears, such as the one in Figure 2b, yielded two patterns (sometimes even four, as in the frontispiece photograph), one where the blade is bound to the midsection and one where the midsection is bound to the shaft. By far the most common style for this second binding is the one shown at the shaft end in Figure 2b. This is the (uncolored) type pmm itself, so classified because the strips of beads divide the white diamonds so that they become 'background', distinct from the dark diamonds which constitute the pattern itself.

The only other two-color patterns (among the 46 mathematically possible) we saw on spear bindings are cmm/pmm, cmm/cm, and cm/pm. A typical example of the common cmm/pmm pattern is shown in Figure 7. Although this is indeed a true two-color pattern of red and white, with *no* background, given its occurrence in the context of so many pmm patterns it could easily be interpreted as just one more red pmm pattern on a white background. Figure 8 shows the typical form in which the two-color pattern cmm/cm appears on these bindings. Figure 9 is a drawing of a typical occurrence of the pattern cm/pm.

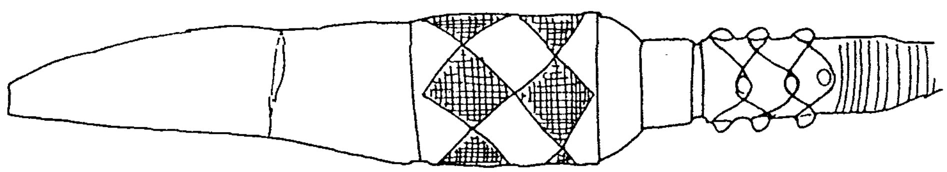

Figure 7: Pattern type cmm/pmm. Red and white. AM E848. (1876-1910)

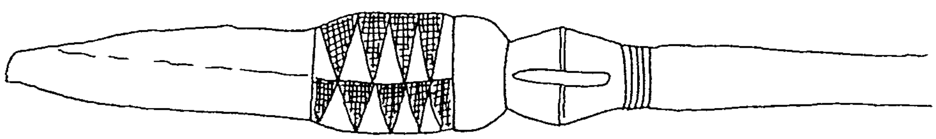

Figure 8: Pattern type cmm/cm. Red and white. AM E19993. (1911-19)

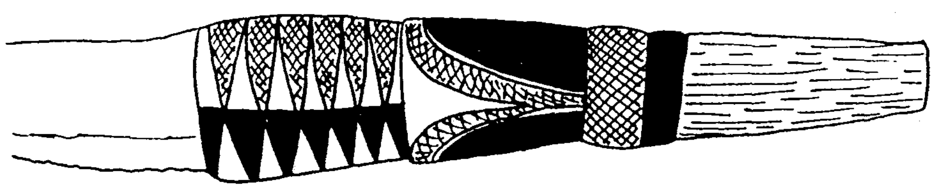

Figure 9: Pattern type cm/pm. Red-black on white background. FM 134186. (1911-19)

The following two Tables give some idea of the relative frequency of occurrence of the five two-colorings of pmm, as well as of pmm itself and the three other types mentioned above. The totals represent the total numbers of recognizable patterns in the spears examined in the two museums, not the number of spears. Table 1 gives the overall frequency of the patterns, while Table 2 divides these into historical periods, insofar as these are known with some certainty. Although the number of spears from the period 1876-1910 is small, the chronological data do seem to show a shift from a predominance of pmm designs, and their colorings, in this earlier period, to a majority of cmm and cm type designs in the next time period.

Pattern Type	Australian Museum	%	Field Museum	%
pmm	14	22	28	16
pmm/pmm	11	17	19	11
pmm/cmm	5	8	6	3
pmm/pm	9	14	17	10
pmm/pmg	9	14	15	9
pmm/p2	1	2	0	0
cmm/pmm	14	22	61	35
cmm/cm	2	3	22	12
cm/pm	0	0	8	5
TOTALS	65	102%	176	101%

Table 1: Number of occurrences of each of the recognizable pattern types in Admiralty Islands spears, by museum location.

Pattern Type	1876-1910	%	1911-1919	%	1920-1940	%	dates unknown
pmm	7	25	27	14	1	14	7
pmm/pmm	5	18	18	10	1	14	6
pmm/cmm	2	7	8	4	1	14	0
pmm/pm	4	14	17	9	1	14	4
pmm/pmg	6	21	15	8	2	29	1
pmm/p2	1	4	0	0	0	0	0
cmm/pmm	2	7	72	39	0	0	1
cmm/cm	0	0	23	12	1	14	0
cm/pm	1	4	7	4	0	0	0
TOTALS	28	100%	187	100%	7	99%	19

Table 2: Pattern types, by historical period.

5 CONCLUSION

In one of the two common versions of Admiralty Islands spears in museum collections the twine which is wound around the wooden collar joining the obsidian blade to the spear shaft produces a natural pattern of rhombuses. By itself this common design, of crystallographic type pmm, is not particularly remarkable, since it is naturally produced by pulling the twine diagonally to form a tight binding of blade to shaft.

It is, however, remarkable that in the process of decoratively coloring the rhombuses (ordinarily with a third color as background) all five 'two-colorings' of pmm have been produced. Thus the combined geometric-permutation problem of finding all possible 'perfect two-colorings' of an underlying pmm pattern was solved, presumably in an entirely intuitive way, by the makers of these spears.

Acknowledgements

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REFERENCES

Coxeter, H. S. M. (1986) Coloured symmetry, In: Coxeter, H. S. M., Emmer, M., Penrose, R., and Teuber, M. L., eds., *M. C. Escher. Art and Science*, Amsterdam: Elsevier, 15-33.

Crowe, D. W. (1971) The geometry of African art I, Bakuba art, *Journal of Geometry*, 1, 169-182.

Crowe, D. W. (1975) The geometry of African art II, A catalog of Benin patterns, *Historia Mathematica*, 2, 253-271.

Crowe, D. W. (1982) The geometry of African art III, The smoking pipes of Begho, In: Davis, C., Grünbaum, B., Sherk, F. A., eds., *The Geometric Vein: The Coxeter Festschrift*, New York: Springer, 177-189.

Crowe, D. W. (submitted) Tongan symmetries, Proceedings of the *Science of Pacific Island Peoples Conference*, Suva, July 1992.

Crowe, D. W., and Nagy, D. (1992) Cakaudrove-style *masi kesa* of Fiji, *Ars Textrina*, 18, 119-155.

Crowe, D. W., and Washburn, D. K. (1985) Groups and geometry in the ceramic art of San Ildefonso, *Algebras, Groups and Geometries*, 2, 263-277.

Moseley, H. N. (1877) On the inhabitants of the Admiralty Islands, *Journal of the Anthropological Institute of Great Britain and Ireland*, 6, 379-429.

Torrence, R. (1989) Obsidian-tipped spears and daggers from the Admiralty Islands, *Report* submitted to The Australian Museum.

Torrence, R. (1993) Ethnoarchaeology, museum collections, and prehistoric exchange: Obsidian-tipped artifacts from the Admiralty Islands, *World Archaeology*, 24, 467-481.

Washburn, D. K., and Crowe, D. W. (1988) *Symmetries of Culture: Theory and Practice of Plane Pattern Analysis*, Seattle: University of Washington Press, x + 301 pp.