2006

Elemental Pathways in Fiber Structures: Approaching Andean Symmetry Patterns through an Ancient Technology

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Repetitive pattern is laden with meaning in many cultures. In Andean cultures, where no alphabetic writing system was developed during prehispanic times, patterns and graphic codes carried a large cultural load. It is crucial to have appropriate tools to investigate the integrated properties (symmetry, color, number, direction, etc.) in the graphic codes of the ancient Andes. In this paper, I will propose some modifications to the prevailing approach to symmetry classification that better fits the patterns in Andean textiles.

Approaches to Symmetry Patterns, Modern and Ancient

An approach to classifying symmetry patterns that is called "plane pattern analysis" has been developed during the 20th century. It grows out of the study of the structures of crystals (crystallography) and group theory, a branch of mathematics (Washburn and Crowe, 1988: 3-41). While this approach allows the classification of patterns according to precepts in western mathematics and science, the resulting classification has little to do with the indigenous categories or the processes involved in the generation of Andean patterns. People of the ancient Andes obviously had an altogether different starting point and rules for generating patterns than those used by 20th century scientists.

My research into several styles leads me to the conclusion that Andean symmetry patterns were conceptualized as pathways in space, and that Andean people drew on several models for pathways. The model that I will discuss resides in fiber technology. The geometric patterns based on this model often look like twisted cords and interlaced elements in fabric structures (Frame 1986, 1988, 1991, 1999, 2001). Another model for symmetrical patterns appears to be the locomotory pathways of mythical humans and animals (Frame 2004). The different models give rise to subtly different symmetry classes, because the walking, swimming, flying, crawling, and swinging motions of mythical figures are conventionalized in a different kind of space than the twisting and interlacing motions of elements in a fibrous matrix. The fact that I can point to two different models for symmetry patterns in ancient Andean art – fiber element pathways and locomotory pathways – raises the question: Is the crystallography approach to plane pattern analysis appropriate for all Andean patterns?

First, I will review a few aspects of the crystallography approach, in order to locate the modifications that I will propose for the Andean patterns under discussion. The crystallography approach limits the four motions that generate symmetrical patterns to rigid motions in the Euclidean plane (fig. 1). The motions are translation (exact copies); reflection (transformed as in a mirror); glide reflection (mirrored and slid forward); and rotation (transformed by spinning 180° around a point in the plane).

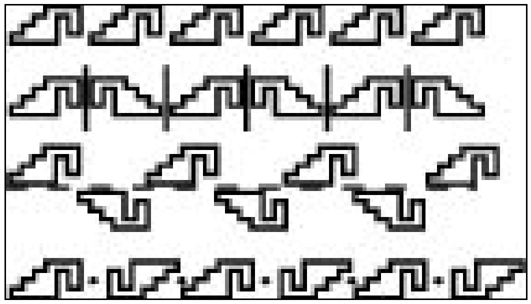

Figure 1. The four motions in the Euclidean plane, according to the crystallography approach: translation, reflection, glide reflection, and rotation.

Using the limitation to motions in the plane, mathematicians can assert that there are seven groups of 1-dimensional patterns, sometimes called strip, band, or frieze patterns (fig. 2). The seven classes, or groups, are generated by the four motions or combinations of the four motions. There are two types of reflection symmetry (across vertical and horizontal axes), and the final two groups combine several of the four motions. Mathematicians can also assert that there are 17 classes of 2-dimensional, or field, patterns (Stevens 1981:335-341; Washburn and Crowe 1988:61) by sticking to their rule that only motions in the Euclidean plane are admitted.

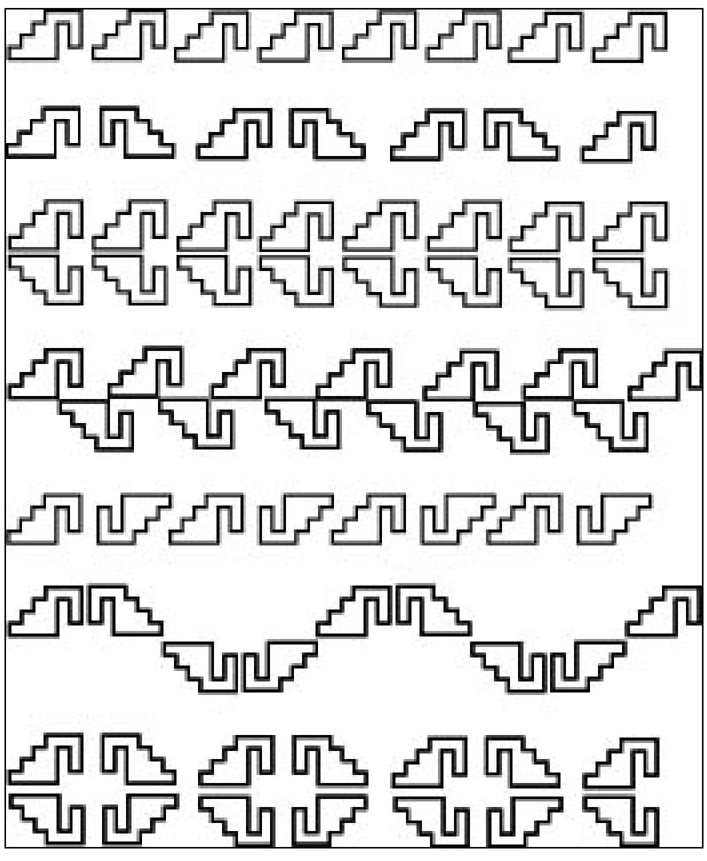

Figure 2. The seven classes of band patterns, according to the crystallography approach.

In the case of Andean patterns that appear to be modeled on fiber structures, I am going to question two fundamental tenets of the crystallography approach to symmetry: the limitation to motions in the plane and the nature of the plane itself.[1] The patterned plane used by mathematicians is the Euclidean plane, which is an abstract expanse with length/width, but absolutely no depth. The Euclidean plane is an abstract invention of the Greeks, or their predecessors, that we happen to be heir to. The ancient Andean people did not share this abstraction, but they did have something tangible that was just as serviceable for conceptualizing spatial dimensions.

The "Thick" Andean Plane

In the Andes, people apparently took some of their ideas of 1- and 2-dimensional space from their experience in making things. I suggest that fiber technology is a likely locus for Andean spatial ideas for several reasons. Fiber elements react predictably to the constraints of space, and are therefore consistent. Secondly, there is a logical progression from the linear elements to planar cloth. Thirdly, fiber was a universally practiced technology, and so was understood experientially by everyone. The final and most compelling reason is that their planar patterns often depict, or at least conform to, the structures of fiber elements and cloth (fig. 3). Instead of the 1-dimensional line of Euclidean geometry, I suggest that the Andean people had linear elements that were spun, plied, or braided; instead of the Euclidean plane, I suggest that they had an expanse of interworked fabric.[2] As textile people know, there is a lot going on inside a plied element and an interworked fabric in terms of motion, direction, and up-down relationships. When Andean people created band or field patterns that mimic fiber structures, they preserved the motions, directions, and relationships of the tangible models through artistic conventions.

Figure 3. Tapestry, c. 400 B.C., with patterns modeled on twisted elements, above, and interlaced elements, below. Private collection.

[1] Grünbaum (2004:18-19) and Washburn (1977) have suggested that the Euclidean plane, which is isotropic (equivalent in all directions), may be the wrong type of plane for symmetry analysis. However, they limit their suggestions for modifications to the Euclidean plane to distinguishing preferred directions (vertical and horizontal).

[2] Andean people also excelled at making double-cloth, even triple- and quadruple-cloth, which could suggest that 3-dimensional space was thought of as multiple layers of planes.

The first way I would like to modify the approach to plane pattern analysis is in how the plane is defined. The Andean plane appears to be a "thick" plane, like a piece of cloth, and it has motions, directions, and relationships within it.

Helical or Axial Rotation

The second modification that I propose to plane pattern analysis is connected to the first. If we recognize the "thickness" of the Andean plane, then we should recognize the twisting motions of elements that are inside the cloth-like plane. I would call this motion helical or axial rotation because the structural pathway of plied and replied cords is a helix that rotates around a longitudinal axis. This is a different kind of rotation than rotation around a point in the Euclidean plane, which is flat and circular.

If we look at examples of actual cords, most people have no problem in agreeing that the symmetry of the cord is helical rotation around an axis, even when it is a drawing or photograph. We know how elements are plied together and, whether we see an actual cord or a flat image of a cord, we recognize the motion of helical rotation around an axis that is imparted by the twirling spindle. Ancient people of the Andes were spinners too; how could they help but register the symmetrical motion in an image as helical rotation?

There are a great number of band patterns, as well as some field patterns, in Andean art that depict helical rotation naturalistically or in a conventionalized manner (fig. 4). The naturalistic rendering of helical rotation shows one surface of a twisted or plied element with overlapping elements sometimes hidden from view behind others (fig. 4, top). A common convention applied to some patterns generated by helical rotation is the attachment of heads to both ends of repeated reverse curves. The pattern looks like a closely-spaced string of double-headed serpents (fig. 4, bottom). The heads conventionally depict when an element in the pattern is moving out of view behind another element, or when the element is reappearing (Frame 1986). In other words, the unnatural multiple heads signal that elements are continuous, but are temporarily out of view.

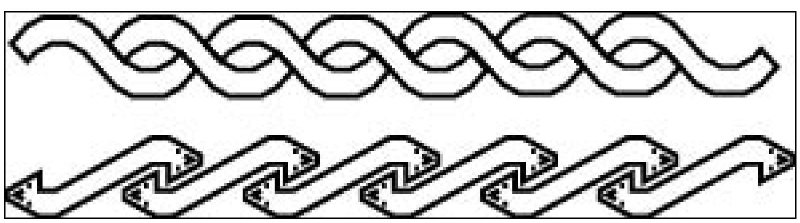

Figure 4. Band patterns that correspond with the motion of helical rotation.

This is such a large class of patterns with so many systematic variants that I suggest they comprise a graphic codification. Number variables in Paracas Necropolis headbands (Frame 1991), represented in color sequences, can span from two to eight and, in other kinds of objects, can run up to fifteen or more. Directional variants, S- or Z-twist, are present among patterns (fig. 4), occasionally on the same artifact. Sometimes, a single pattern band with a counter-twisted element is present among many of the opposite twist. Weaving communities in the Andes still use counter-spun yarns for magical, curative, and ceremonial purposes (Goodell 1969), so we might assume that helical direction shown in a pattern that is much older was also a signifying, graphic property.

The crystallography approach to plane pattern analysis does not admit helical rotation as a motion of symmetry because it is not a motion in the Euclidean plane. If we insist on analyzing patterns of twisting cords as patterns in the Euclidean plane, we may miss the very qualities, such as helical direction, that signified in Andean cultures. Several Andean cultures also had a visual-tactile code that was called the *khipu* in the language of the Inkas. The *khipu* was a record-keeping device constructed of colored cords with knots. Color, direction, and number are integrated properties that signify in *khipu* cords. The planar patterns that show twisting cords also exhibit properties of color, number, and direction, which suggests that the patterns are part of a broader cultural phenomenon that drew on the inherent properties of fiber constructions for the properties of graphic or tactile codifications.

I propose not only that we recognize the “thick” Andean plane and helical rotation as a motion that generates patterns, but also that we integrate symmetry analysis with the analysis of other properties (number, color, and direction) that signify in graphic codes.

Figure-8 Rotation

Another Andean pattern that does not fit in the Euclidean plane has a pathway of a figure-8. The figure-8 is centered on a point, but the pathway traced by the pattern overlaps on itself in a way that requires a “thick” plane to complete itself. I am tentatively calling this motion figure-8 rotation.

This type of finite pattern occurs on very early fabrics from the Preceramic period (c. 2000 B.C.), and it usually takes the form of a double-headed snake that is tightly furled in an S- or Z-shape (fig. 5). The two heads on the snake signal that it is a continuous pathway that is only broken because part of the pathway disappears from view behind another part. What sets the figure-8 pattern apart from patterns that mimic plied cords is that the double-headed snakes are not connected or interlocked: they stand alone, and turn back on themselves. There are two directional variants in the figure-8 patterns that can be termed S- or Z-slant, in accordance with the diagonal stroke that lies across the partly hidden diagonal.

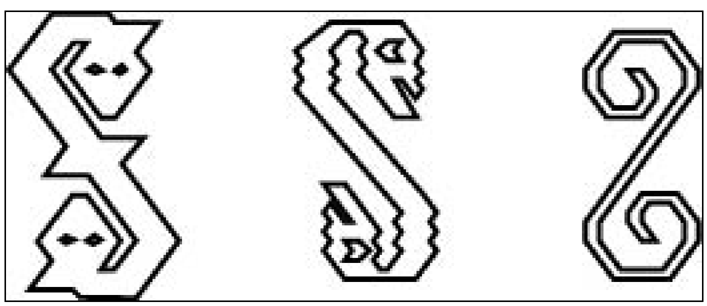

Figure 5. Finite patterns that correspond with figure-8 rotation from Preceramic twined textiles and a contemporary textile.

Figure-8 patterns, with and without the double-headed convention, are found in virtually all Andean styles from the Preceramic to the present, where they sometimes repeat in band or field patterns. In the contemporary weaving community of Chinchero, the figure-8 pattern, which is often centered in a diamond or repeated in a band, is called *kuti* – “that which returns.”

Figure-8 rotation is another motion that I think needs to be recognized in Andean symmetry patterns, partly because this pattern is so widely distributed over a period of 4000 years, and partly because the figure-8 pathway is so mathematically significant in the Andes. The figure-8 is the pathway used in warping: its alternating cycle preserves both the side-by-side sequence of threads and intercalates the up-down alternation of threads in continuous warping. In the Inkan *khipu*, figure-8 knot is used in a unique capacity: it is the knot that denotes only the number 1.

Helical Rotation in Four Directions

The final type of pattern to be described is the most complicated. I argue that it, too, is a pattern that is generated by helical motions that do not fit in the Euclidean plane. This unusual pattern is found on some Wari tunics (fig. 6), which are high status, tapestry-woven garments for men (c. 550 - 700 A.D.). The majority of tunics are patterned in vertical bands that have plain bands between them. Tunics exhibit different numbers of patterned bands, and different numbers of strip patterns within patterned bands (usually one, two, or three). When there is more than one strip pattern per band, they repeat in reflection symmetry. Generally, the patterns alternate one or two figures in different orientations. The most commonly repeated motifs are stepped frets and profile faces.

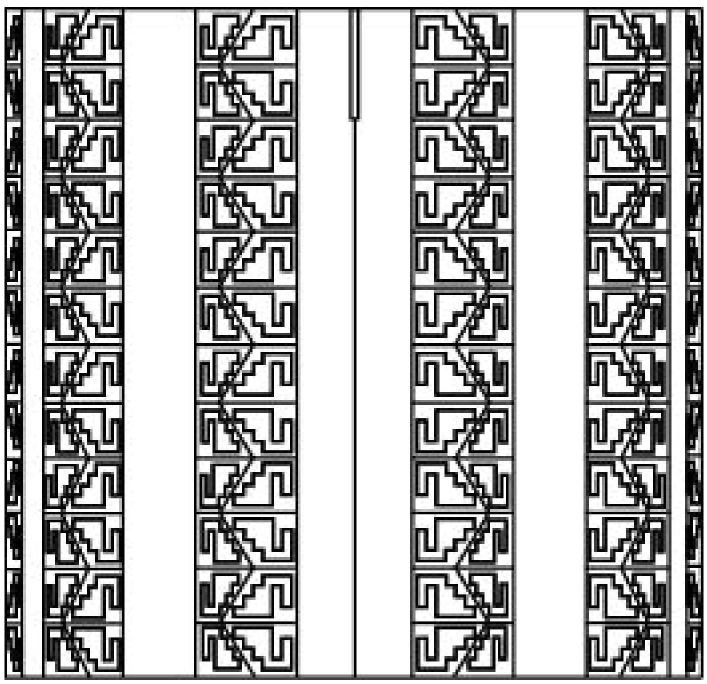

Figure 6. Wari tunic with stepped frets repeated in strip patterns, one per band.

To illustrate how this pattern corresponds with helical motions in the "thick" Andean plane, the simplest version of the pattern will be used.[3] The pattern consists of only one motif, the stepped fret, which repeats in four orientations in a single strip pattern (fig. 6). The stepped fret is an asymmetrical motif that has three directional distinctions. It has a broad, flat base and narrower top, giving it an up-down distinction; a curling fret on one side, giving it a left-right distinction; and a diagonally slanted back, giving it an S- or Z-slant distinction.

Stepped frets are regularly repeated in four orientations that can be distinguished by their directional attributes. The frets that have the same orientation are highlighted in four diagrams of

[3] There is a curious kind of distortion in the strip patterns on most tunics. One side of each band is expanded and the other side is compressed (Sawyer 1963). This distortion does not affect the symmetry pattern, but does produce an effect like perspective, which makes the strip pattern appear rounded, like a cylinder.

the same band (fig. 7). The helical direction of a pathway corresponds with directional attributes in the highlighted step frets, that is, the S- or Z-slant of the stepped diagonal and the up-down distinction between base and top. The curling hook at the top of the fret suggests both a leftward/rightward trending of a pathway and the curling motion around the axis. Reading across the bands in figure 7, the corresponding helical pathways are Z-up, S-up, S-down, and Z-down, which are shown in the paired diagrams of an element with an arrowhead wrapping around a cylinder.

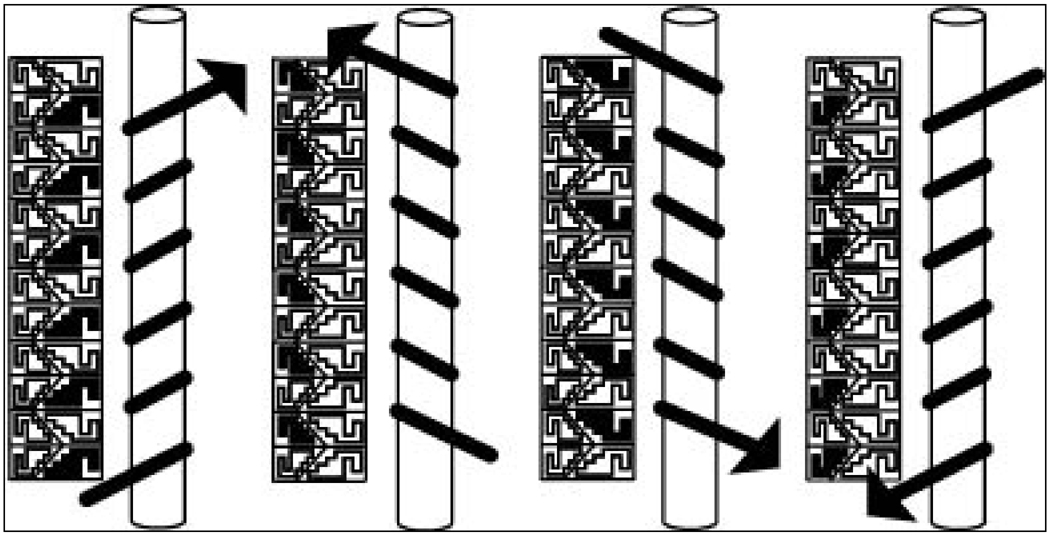

Figure 7. The four helical pathways that correspond with the band pattern can be described in combinations of S/Z and up/down: Z-up, S-up, S-down, Z-down (from left to right).

The helical pathways correspond with a fiber structure where elements wrap around a core or axis. Helical wrapping is not a fabric structure but rather, it is a veneer of elements wrapped in different directions around a core. Patterns are built up progressively by wrapping in different directions with different colored elements. Wrapped structures are found on spinning distaffs, hair hanks and wigs, bamboo needle cases, as well as some non-Inka *khipus*.

While this strip pattern could be analyzed using the crystallographic approach,[4] the combination of symmetries in the Euclidean plane does not correspond with any fiber structure or with any other Andean logic that I am familiar with. An additional reason for thinking that strip patterns in Wari tunics were generated by helical rotation in four directions lies in the *khipus* of this period. *Khipus* that date to the Wari period were adorned with helical wrapping, unlike the Inka *khipus* (Conklin 1982). Some *khipu* cords have a diamond pattern, which uses the four directional pathways of wrapping to make the four sides of the diamond. This connection between the *khipu* technique and the helical pathways of the symmetry pattern has another suggestive facet: the tunics look something like *khipus* (fig. 6). The tunics are vertically banded, like the parallel cords, and the compression and expansion of the patterned bands suggests the cylindrical shape of *khipu* cords through perspective.

Directional pathways are imbued with significance in Andean activities such as dance, processions, ceremonies, and textiles. On a ritual pilgrimage to a snow-capped mountain called

[4] Using the crystallographic approach with its limitation to motions in the Euclidean plane, this pattern could be described as having rotation symmetry between side-by-side frets; reflection symmetry between vertically adjacent frets; and glide symmetry between vertical pairs of frets.

Qoyllur Rit'i, pilgrims sometimes stop in their arduous climb to twist grass that grows along the side of the path: they twist it with their left hand held behind their back. The leftward twisting purges their sins, which they leave behind them in the grass (Allen 2002:167). The cultural importance of direction in the Andes suggests why ancient patternmakers might have developed a systematic approach to symmetrical repetition that was conceptualized in terms of directional pathways. The pattern that appears on Wari tunics (fig. 7) is the most complex union of directional pathways in a strip pattern that I am aware of in all of Andean art.

Conclusions

My proposal to modify the prevailing approach to plane pattern analysis arises from what I observe in Andean patterns and culture. I suggest that motions that are outside of the Euclidean plane (but inside the "thick" Andean plane) need to be recognized in Andean symmetry patterns. Although I have dealt with only a few of the modifications in this paper, the motions of helical rotation and figure-8 rotation are sufficient to signal deficiencies in the crystallography approach in the case of Andean patterns. The patterns that I illustrate correspond with figure-8 rotation (fig. 5), and with helical rotation on one directional pathway (fig. 4) and on four directional pathways (fig. 7). I propose that these additional motions of rotation should be recognized, in addition to point rotation in the Euclidean plane.

There is good news and bad news in what I suggest. The bad news is that pattern analysis is not so neat nor so limited as it is in the crystallography approach - there are more symmetry motions, more pattern classes, and more interrelated properties to consider. The good news is that I think a modified approach to symmetry analysis holds promise for increasing our understanding of ancient graphic codes used in the Andes. Those who deal with patterns in different cultures may discover that different modifications to the crystallography approach are called for, especially if symmetry patterns are not conceptualized as pathways in a thick plane or modeled on fiber technology. I suspect that indigenous approaches to generating symmetrical patterns will be multiple, given that my research into Andean symmetry patterning indicates that at least two models were used to produce slightly different symmetry systems.

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