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Anisotropy of Magnetic Susceptibility Parameters: Guidelines for their Rational Selection

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Abstract—Twenty-eight parameters used to characterize measurements of the anisotropy of magnetic susceptibility are compared theoretically in this work by introducing the concept of the field of susceptibility tensors, which allows the representation of parameters as families of lines in a plane. It is demonstrated that the foliation and lineation parameters are but a special case of the shape parameters, implying that the resolution of these two rock fabric elements using AMS measurements alone is more an artifact of the numerical range of definition of some parameters than a quantification of two physically independent features. Also, it is shown that parameters presumably of the same type do not necessarily yield equivalent interpretation of results in a qualitative sense, and therefore, caution should be strongly exercised when parameters are to be selected. Parameters quantifying the degree of anisotropy are, in general, equivalent to each other because of the very small departure observed in natural rocks from the isotropic case. However, a final consideration of the possible ability to differentiate rock types and a convenient range of values allowing expression of the degree of anisotropy in a well-defined percentage are pointed out as the main factors to be considered before selecting one parameter within this class.

Key words: Magnetic susceptibility, AMS parameters, magnetic fabrics, degree of anisotropy.

Introduction

Due to the interest in the determination of the low-field anisotropy of magnetic susceptibility (AMS) because of its value as a petrofabric indicator, numerous anisotropy factors have been proposed. The selection of suitable parameters is one of the most fundamental aspects of any AMS study, yet at present there are no objective criteria for deciding which parameters should be used (see e.g., HROUDA, 1982). In an effort to alleviate this situation, ELLWOOD *et al.* (1988) suggested some criteria, within an instrumental basis, to select parameters. They pointed out that some methods of measurement favor the use of parameters that include the differences of the principal susceptibilities, while others call for the use of their

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ratios (see also HROUDA and JELINEK, 1990). However, they overlooked the fact that most of the available parameters use both ratios and differences of the principal susceptibilities in their definitions and, as will be shown later, given the small departures from the isotropic case that are usually observed in rock specimens, there is no practical difference between both types of parameters. Another important aspect of this problem was also highlighted by ELLWOOD *et al.* (1988) and TARLING (1983), who mentioned that the actual calculation of different parameters reduces to a simple arithmetical combination of the principal susceptibilities, provided that these can be uniquely determined, and consequently, all of them are interdependent to some extent. Therefore, the need for more structured criteria that can be used to select AMS parameters has not yet been completely satisfied.

In practice, four classes (foliation, lineation, shape and degree of anisotropy) of AMS parameters are used to make quantitative comparisons of the properties that they are supposed to be estimating and, commonly, it has been assumed that the selection of a particular parameter within each of these classes is unimportant (RAHMAN *et al.*, 1975; TARLING, 1983), i.e., it is expected that any two parameters within the same class will yield very similar, if not identical, qualitative results. However, this assumption was never proved, and as will be illustrated later, it was not completely justified in some cases.

In this work, a mathematically oriented point of view was used to make a theoretical comparison among 28 AMS parameters (see Tables 1 and 2), allowing the formalization of the equivalences between some of them. The theoretical comparison was made by introducing a suitable representation of the field of susceptibility tensors, in which parameters could be conveniently expressed as families of lines; constraining the area of interest to the range of expected experimental values proved to be important in the establishment of equivalences. It is important to mention that, with this approach, parameters are examined independently of their physical definition, i.e., whether they were first proposed as measuring magnetic foliation or degree of anisotropy is not important; the emphasis is rather made on some of their mathematical properties such as range of definition and distribution of this range within the field of susceptibility tensors, and also in the qualitative results that are expected from the use of a given parameter. The latter aspect was approached by using actual values of the principal susceptibilities taken from several rock types to test the validity of the theoretical considerations and, ultimately, to justify the suggested reduction to only two different classes of parameters. In any case, the purpose of this work is to offer to the interested reader the opportunity to compare parameters in a more structured and objective manner than possible to date, allowing him (her) to decide which parameters are more convenient for his (her) particular interests.

Table 1

Shape parameters. $n_i = \ln(k_i)$, *i = 1, 2, 3 and* k_m *is the arithmetic mean of the principal susceptibilities*

	Parameters	Name	Range	Group	Source
1)*	$(k_1 - k_2)/(k_2 - k_3)$	Prolateness	0–. . .		KHAN (1962)
2)**	$(k_2 - k_3)/(k_1 - k_2)$	Oblateness	0–. . .		KHAN (1962)
3)	$a \sin\{(k_2 - k_3)/(k_1 - k_3)\}^{1/2}$	Angle V	0–90		GRAHAM (1966)
4)	$(2k_2 - k_1 - k_3)/(k_1 - k_3)$	Difference shape factor	−1–1		JELINEK (1981)
5)	$(k_1 - k_2)/\{(k_1 + k_2)/2 - k_3\}$	q factor	0–2	S1	GRANAR (1957)
6)*	$(k_2(k_1 - k_2))/(k_1(k_2 - k_3))$		0–. . .		JANÁK and HROUDA (1969)
7)*	$(k_3(k_1 - k_2))/(k_1(k_2 - k_3))$	Shape indicator	0–. . .		STACEY *et al.* (1960)
8)**	$(k_2/k_3 - 1)/(k_1/k_2 - 1)$	D factor	0–. . .		HROUDA (1976)
9)	$(2n_2 - n_1 - n_3)/(n_1 - n_3)$	Shape parameter (T)	−1–1		JELINEK (1981)
10)*	k_1/k_2	Lineation	1–. . .	S2a	BALSEY and BUDDINGTON (1960)
11)*	$(k_1 - k_2)/k_m$	Magnetic lineation	0–3		KHAN (1962)
12)**	$(k_2 - k_3)/k_m$	Magnetic foliation	0–1.5		KHAN (1962)
13)**	k_2/k_3	Foliation	1–. . .	S2b	STACEY *et al.* (1960)
14)**	$1 - (k_3/k_2)$	Foliation	0–1		PORATH (1971)
15)	$k_1 k_3/k_2^2$		0–. . .		STACEY *et al.* (1960)
16)	$k_2^2/k_1 k_3$	E factor	0–. . .	S2	HROUDA *et al.* (1971)
17)	$k_3/k_1 - 2k_2/k_1 + 1$	B parameter	−1–1		CAÑÓN-TAPIA (1992)

Table 2

Degree of anisotropy parameters. $a_i = \ln(k_i/k'_m)$, $i = 1, 2, 3$ *and* k_m, k'_m *are the arithmetic and geometric means of the principal susceptibilities, respectively*

	Parameter	Name	Range	Group	Source
1)	k_1/k_3	Anisotropy degree (*P*)	1–. . .		NAGATA (1961)
2)	$100(k_1 - k_3)/k_1$	Percentage anisotropy	0–100		GRAHAM (1966)
3)	$(k_1 - k_3)/k_m$	Total anisotropy (*H*)	0–3	A1	OWENS (1974)
4)	$(k_1 - k_3)/2k_m$	Percentage anisotropy	0–1.5		KHAN (1962)
5)	$(k_1 - k_3)/k_2$	Absolute anisotropy	0–. . .		REES (1966)
6)	$(k_1 + k_2)/2k_3$	Foliation	1–. . .	A2	BALSEY and BUDDINGTON (1960)
7)	$((k_1 + k_2)/2) - k_3$	Magnetic excess	0–1 ($\times k_1$)		GRANAR (1958)
8)	$\exp\{2[(a_1)^2 + (a_2)^2 + (a_3)^2]\}^{1/2}$	Corrected anisotropy degree (*P'*)	1–. . .	A3	JELINEK (1981)
9)	$k_1/(k_2 k_3)^{1/2}$	Emplacement factor	1–. . .		ELLWOOD (1975)
10)	$2k_1/(k_2 + k_3)$	Lineation degree	1–. . .	A4	HROUDA *et al.* (1971)
11)	$100(1 - k_3/2k_1 - k_2/2k_1)$	A parameter	0–100		CAÑÓN-TAPIA (1992)

The Field of Susceptibility Tensors

Magnetic susceptibility, a physical property of matter, is mathematically approximated by a second-order symmetric tensor (NYE, 1960) whose eigenvalues are referred to as the principal susceptibilities. The magnetic susceptibility measured in most rock specimens is frequently dominated by the ferro- and paramagnetic mineral fractions of that rock and, therefore, it will usually satisfy the condition

$$k_1 \geq k_2 \geq k_3 > 0. \tag{1}$$

In the very uncommon event that at least one of the principal susceptibilities is smaller than zero (e.g., ABOUZAKHM, 1974), the following arguments would not be directly applicable, although the very nature of the dominance of a diamagnetic fraction in a given direction indicated by a negative susceptibility, would require further investigation before attempting to make any other interpretation of the data. Moreover, the qualitative aspects of this work would not be changed in these anomalous cases, and therefore only the general case expressed by eq. (1) will be addressed here.

KHAN (1962) used k_2 as a normalizing factor in (1), leading to

$$k_1/k_2 \geq 1 \geq k_3/k_2 > 0. \tag{2}$$

The ratios thus obtained can be used as a coordinate pair to define a region in a plane (Fig. 1a) in which each point represents one particular type of susceptibility tensor (see examples below). The association of one type of tensor with a point in a plane is analogous with the usual representation of the field of the real numbers in the numerical line, and therefore, the region of the plane in which this relationship holds (the area enclosed by the line segments *ID*, *IR* and the 'x' axis) will be referred to as the field of the susceptibility tensors.

The representation of the field shown in Figure 1a, will always be incomplete because it requires an infinitely long plane to include all the susceptibility tensors that satisfy (1). However, using k_1 as the normalizing factor, (1) would transform differently, leading to the representation shown in Figure 1b. In this new representation it is possible to include all the susceptibility tensors satisfying (1) in a finite area, while keeping the association of one point with one single type of susceptibility tensor unaltered. For example, all isotropic tensors ($k_1 = k_2 = k_3$) are represented by the point I in both Figures 1a and 1b; and similarly, the case when $k_1 = k_2$ and $k_3 = 0$ will be denoted by the point D in both figures. However, note that the case where $k_2 = k_3 = 0$ can be exactly located only in Figure 1b (point R). In order to make the most generally possible comparison among parameters, it is convenient to have at sight the complete field of susceptibility tensors represented on a finite area, and therefore, the representation shown in Figure 1b was preferred in this work. It seems important to remark at this juncture that the ratios k_2/k_1 and k_3/k_1 as used up to this point, have been selected because of the relationship of order that

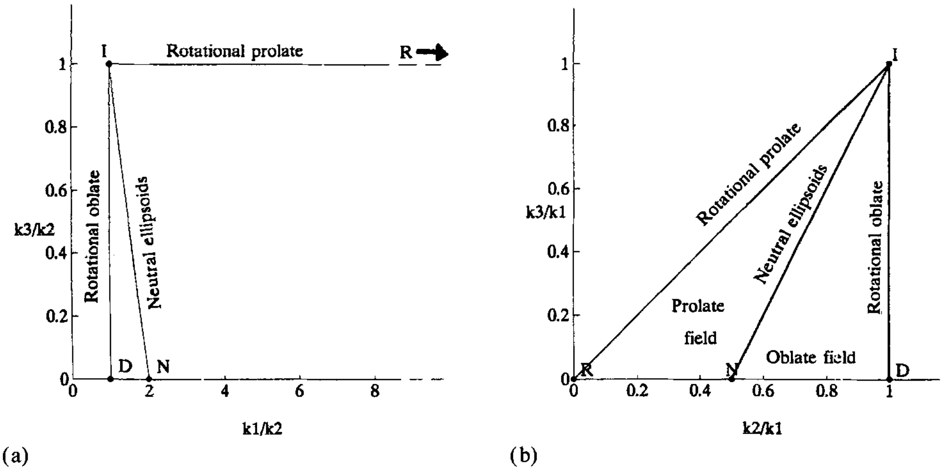


Figure 1
Two different representations of the field of the susceptibility tensors defined by using a) k_2 and b) k_1 as rationalizing factors.

the three principal susceptibilities must satisfy, and in that sense are unrelated to such concepts as degree of anisotropy or magnetic foliation. The association of these ratios with those quantities is made in the following sections.

Parameters as Families of Lines

AMS parameters can be represented by families of lines in the field of susceptibility tensors; each value of a given parameter corresponding to one particular line. This geometrical representation of parameters reduces the task of comparing them to their associated families of lines.

The process for expressing the parameters as lines in the field of the susceptibility tensors consists of four main steps, the first of which is the identification of all the susceptibility tensors that yield the same value of one given parameter. Secondly, by using some elementary algebra, the condition of constant value is expressed in terms of the ratios k_2/k_1 and k_3/k_1 and the resulting expression is associated with the general form of one type of curve in a coordinate plane. Finally, variation of the numerical value of the parameter within the possible range allows the definition of the corresponding family of lines.

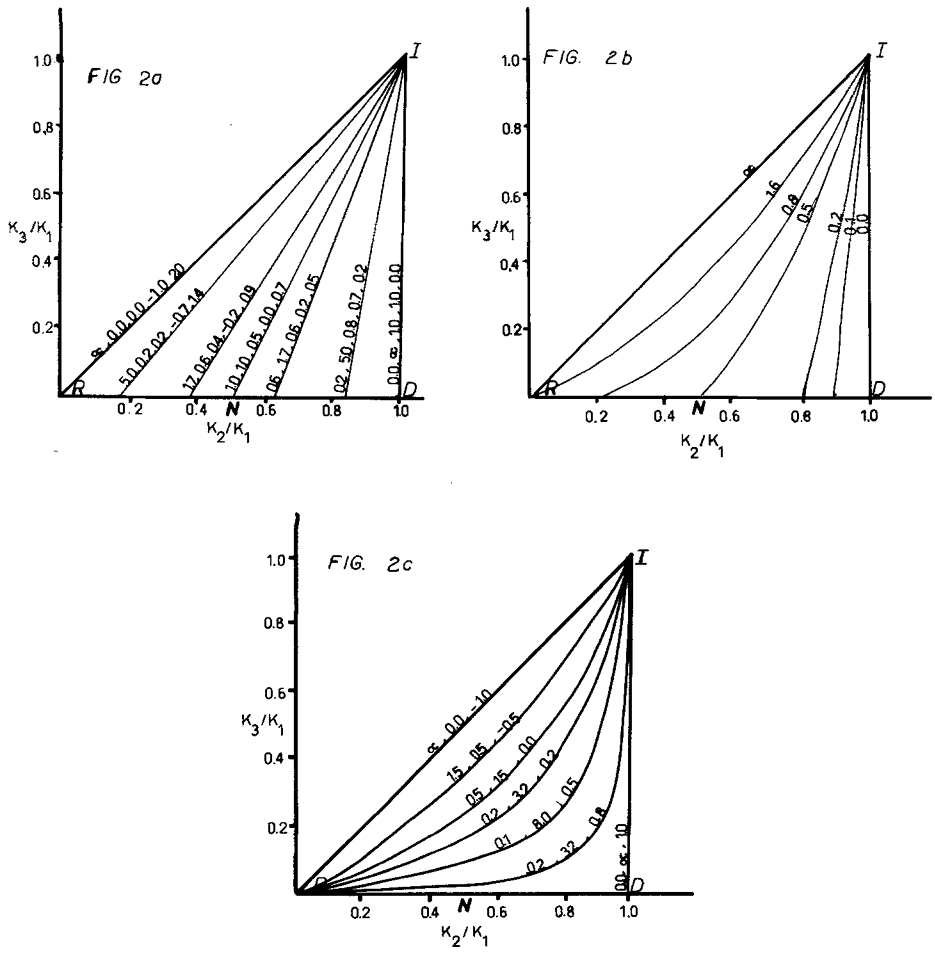
For example, all the tensors with a constant value, say n, of the prolateness parameter (number 1 in Table 1) will satisfy the condition

$$(k_1 - k_2)/(k_2 - k_3) = n. \tag{3}$$

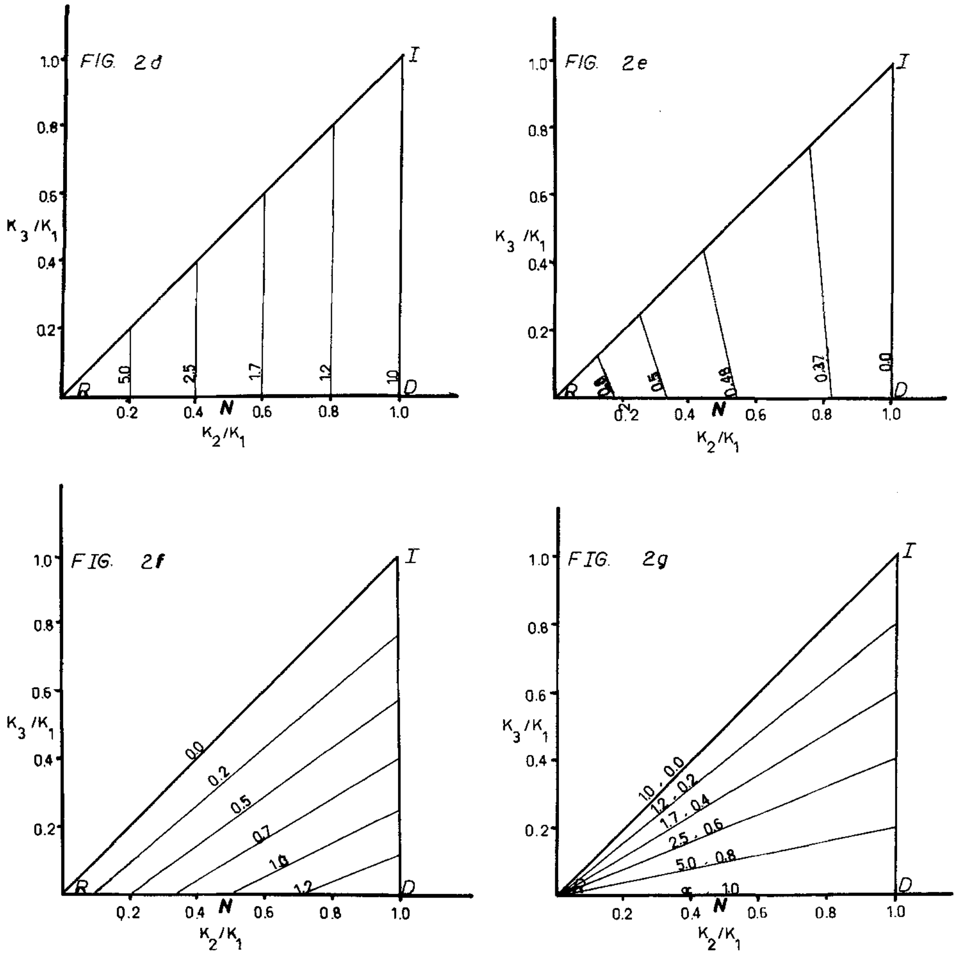
Dividing by k_1 both numerator and denominator of the left side of (3) and rearranging terms, the expression

$$[k_3/k_1] = [(n+1)/n][k_2/k_1] - 1/n \tag{4}$$

is obtained. Equation (4) has the general form of a straight line in a coordinate plane ($y = mx + b$) and therefore, the prolateness parameter will be represented by a family of straight lines. Inserting in eq. (4) different values of n that are within the range of possible values for this parameter (Table 1), it is found that the family of lines is such that they converge at I (Fig. 2a); the slope of any particular line and the value of its zero ordinate depending on the particular value of n.



Figures 2(a–c)



Figures 2(d–g)

Another example is the parameter V that is given as parameter 3 in Table 1. First, identification of all the tensors with the same value of V, say n, is made by applying the expression

$$(k_2 - k_3)/(k_1 - k_3) = \sin^2 n = m. \tag{5}$$

Dividing by k_1 the numerator and denominator of the left-hand side of (5), and rearranging terms as before, we obtain

$$[k_3/k_1] = [1/(1 - m)][k_2/k_1] + m/(m - 1). \tag{6}$$

This new expression also has the form associated with straight lines on a plane. Variation of the values of m, again defines the family of lines converging at I, as

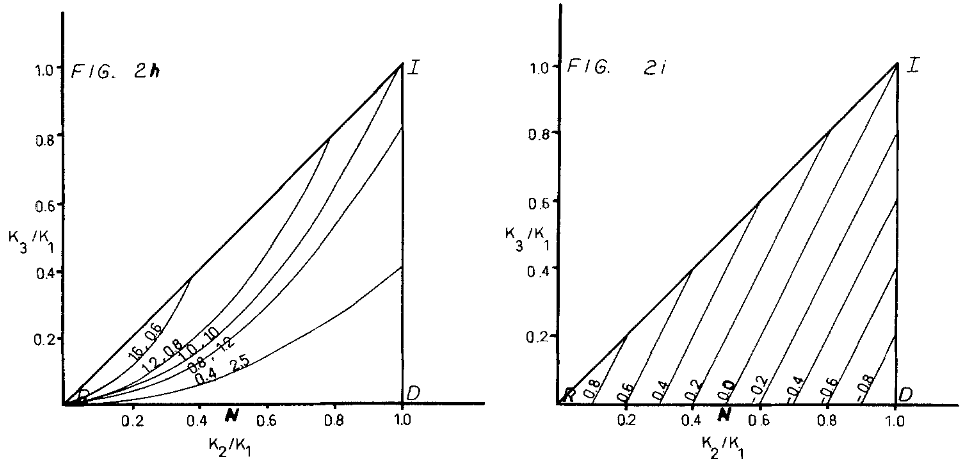


Figure 2(h -i)

Figure 2

Families of lines representing different categories of susceptibility tensors defined by the parameters listed in Table 1. The numbers on the lines are the required values of those parameters to generate the corresponding line. a) Parameters 1 to 5, b) 6, c) 7 to 9, d) 10, e) 11, f) 12, g) 13 and 14, h) 15 and 16 and i) 17.

in the case of the prolateness parameter. This procedure was used with all the 28 parameters listed in Tables 1 and 2 (Figs. 2 and 4). Note that all the families of lines associated with parameters on Table 1 are such that no single line intersects simultaneously both segments *IR* and *ID* that limit the field of the susceptibility tensors while those on Table 2 do. This characteristic was used to divide parameters in the two types discussed in the two following sections.

Shape Parameters

Theoretical Aspects

Following the procedure described above with each of the 17 parameters listed in Table 1, the family of lines generated by each parameter can be found, resulting in the 9 different families of lines shown in Figures 2a–2i. It can be observed that parameters 1 to 5 all give place to the same family of straight lines converging at the point *I*. As it would be impossible to identify which parameter was used to generate the family of lines illustrated in Figure 2a without examining a specific numerical value over one particular line, it is reasonable to assure that all these parameters are mutually completely equivalent.

From Figures 2a–2i, it is observed that above some critical value of the ratio k_3/k_1, some families of lines are very similar to each other. For example, parameter 6 of Table 1 (Fig. 2b), generates a family of parabolae and parameters 7, 8 and 9 (Fig. 2c) are represented by a family of hyperbolic curves which for values of $k_3/k_1 > 0.3$ can be approached by straight lines converging to *I*. Therefore, these four new parameters can be regarded as being equivalent to the first five, thus defining the group S1 shown in Table 1. Similarly, the vertical lines of Figure 2d (generated by parameter 10) can be approximated very closely by the lines of Figure 2e (generated by parameter 11) for values of $k_3/k_1 > 0.4$ (Group S2a); parameters 12, 13 and 14 (Figs. 2f and 2g), generate a family of straight lines of changing slope which for values of $k_3/k_1 > 0.3$ are very similar to each other (Group S2b) and, finally, the parabolae defined by parameters 15 and 16 (Fig. 2h) are well approximated by the straight lines generated by parameter 17 (Fig. 2i) for values of $k_3/k_1 > 0.3$ (Group 2). Experimentally, a ratio $k_3/k_1 > 0.5$ will be commonly expected, although exceptionally low values ~ 0.2 can be obtained when the magnetic phase contained in the specimen is part of the ilmeno-haematite or pyrrhotite series (NAGATA, 1961), and therefore, the reduction to only four different families of lines, or independent groups of parameters, seems to be justified.

Empirical Aspects

A suite of actual data was compiled from the published literature and used to generate an artificial profile that could be used to compare the different parameters in a qualitative way. Measurements made on individual specimens were preferred over sample means, and the availability of such data mostly determined the selection of the sources used. The first 12 samples are specimens taken from lava flows from two different volcanoes (CAÑÓN-TAPIA *et al.*, 1993a,b), samples 13 to 18 are from the Koolau volcano dyke complex (KNIGHT and WALKER, 1988), 19 to 24 are from the Whin sill (ABOUZAKHM, 1974), 25 to 30 are peridotites from the Venezuelan province of Tinaquillo (MACDONALD and ELLWOOD, 1988), 31 to 36 are from the Trenton limestone (JACKSON, 1990) and, finally, 37 to 42 are deformed sandstones from the Sudbury Basin (HIRT *et al.*, 1988). From the 42 samples used, each was given a number that corresponds to its vertical position in the "profile"; the exact position was irrelevant for the present purposes, although it was found to be convenient to keep together specimens from the same source as already noted. The value of each parameter was then calculated for each specimen, resulting in 21 profiles similar to those shown in Fig. 3.

In accordance with the theoretical part, four groups of parameters were identified, each formed by a number of parameters that should yield very similar, if not identical, profiles. This was the case for most parameters, with the exception of some belonging to the S1 group. In fact, it was found that the S1 parameters marked with an asterisk in Table 1 yield a curve that only matched with the left side of the profile shown in Figure 3a, while those marked with two asterisks yield a

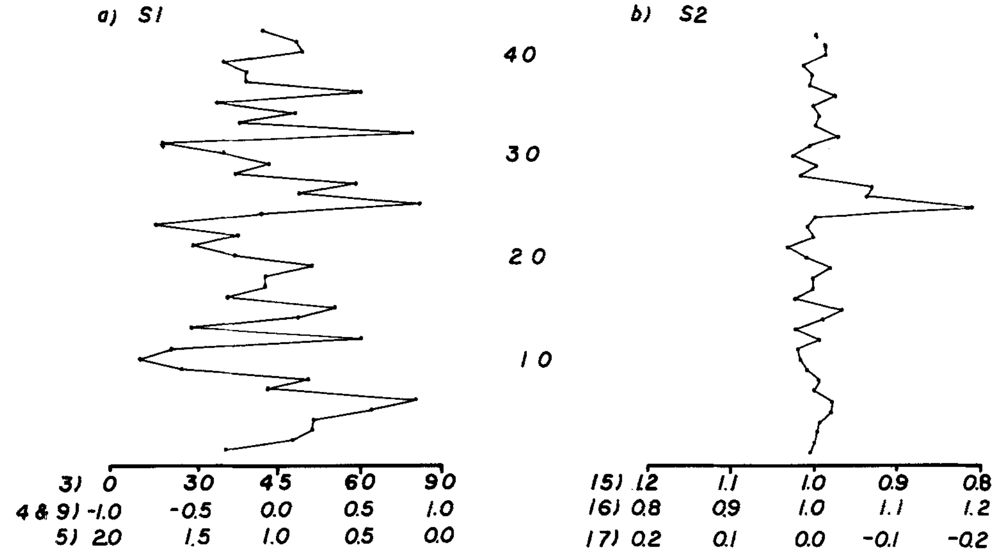


Figure 3
Values of the parameters of Table 1 calculated for the profile constructed with samples of different lithologies. a) S1 group, b) S2. The scales below correspond to the values that are obtained using the parameters indicated in each case by the rightmost numbers. The vertical numbers indicate the specimen number.

curve that only matched its right side. This apparently surprising result is, however, explained by more closely examining the distribution of lines in the field of the susceptibility tensors together with their associated numerical values. In effect, it can be observed that approximately half of the field is covered by lines with values between 0 and a small number (0.5, 1 or 1.5, depending on the specific parameter) while the other half includes lines with values between that number and infinity. This asymmetrical distribution of values results in the stretching of the side of the profile with values larger than the "middle" point, accompanied by the squeezing of the side of the profile with values smaller than it, explaining why only one branch of the profile is well defined.

A similar effect is observed when comparing the profiles resulting from the groups S2a and S2b with that of S2 (Fig. 3b), suggesting then that the former two groups are only a subgroup of the latter, resulting from the limitations imposed by the distribution of numerical values of certain parameters within the field of susceptibility tensors.

The above observations demonstrate that the foliation and lineation parameters (those marked with one and two asterisks in Table 1, respectively) are but special cases of a more general type of parameter, that for convenience can be associated with the usual shape parameters. In other words, it formalizes the notion that usage of a foliation (lineation) parameter necessarily implies a certain degree of "contamination" from the lineation (foliation) present in the rock. A specific example of great importance is that there will be no single tensor for which the values of both foliation and lineation are large, which clearly indicates that it is impossible to resolve between these two rock properties. Under these circumstances, it seems rather impractical to use two different parameters to express the magnetic fabric, when it is possible to use one parameter that will lead in the same way to the identification of rocks with either a prominently developed magnetic foliation or lineation. Note that values close to the middle of the range allowed by the shape parameters (in the sense given in this paper) can be produced in two completely different ways because if both magnetic lineation and foliation are each very well developed they will have the same effect in the magnetic fabrics as if only one of them was very poorly developed while the other was not developed at all. Clearly, the geological interpretation of the shape parameter values must be made in light of the specific situation under study.

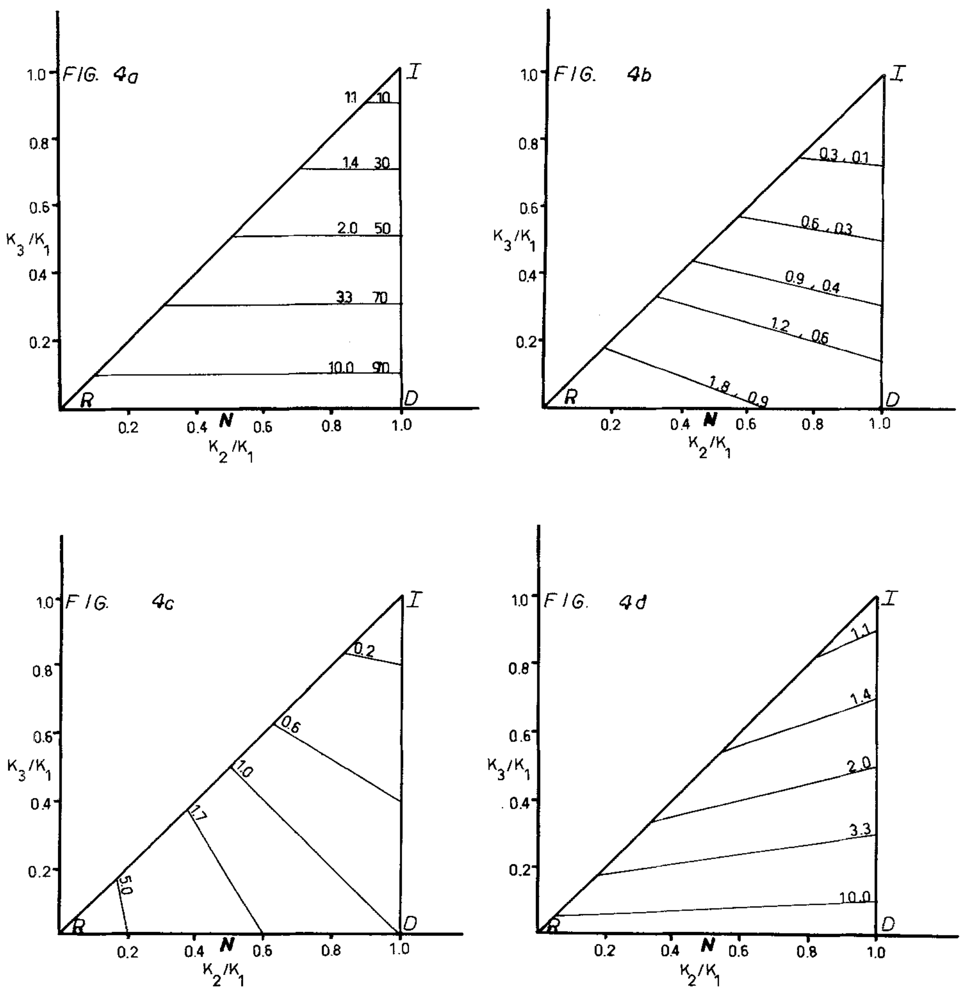
Comparison between the two Groups of Shape Parameters

Although in complete agreement in the way that the specimens are divided between the prolate and oblate shapes by the S1 and S2 groups, some substantial differences exist between the profiles shown in Figures 3a and 3b. In the case of the profile shown in Figure 3a, the numerical data nearly reach the two allowed boundaries (usually -1 and 1) on several occasions, while in the profile shown in Figure 3b the numerical data are always very distant from both boundaries. Also, perhaps more remarkably, in the latter case there seems to be a peak produced by three peridotite samples that is not observed in Figure 3a. At this point there is no way to ascertain whether there is something unique about these samples in a physical sense, or if the apparently large degree of development of the magnetic foliation highlighted by the group of parameters S2 is merely an artifact of the different way in which the parameters are defined. Clearly, a decision of which group of parameters is reflecting a physical reality more closely (i.e., whether there is truly something special about those samples, with respect to some of the Xitle lavas, for example) cannot be made without carrying out further research. However, this difficulty serves to emphasize that the use of two parameters belonging to the same class (shape parameters in this case) may sometimes lead to substantially different interpretations of results, and therefore it would seem reasonable to continually use one parameter of each of these two groups (S1 and S2, excluding those marked with asterisks) in all AMS studies. Certainly, if no qualitative difference between them is observed, results of only one parameter should be reported.

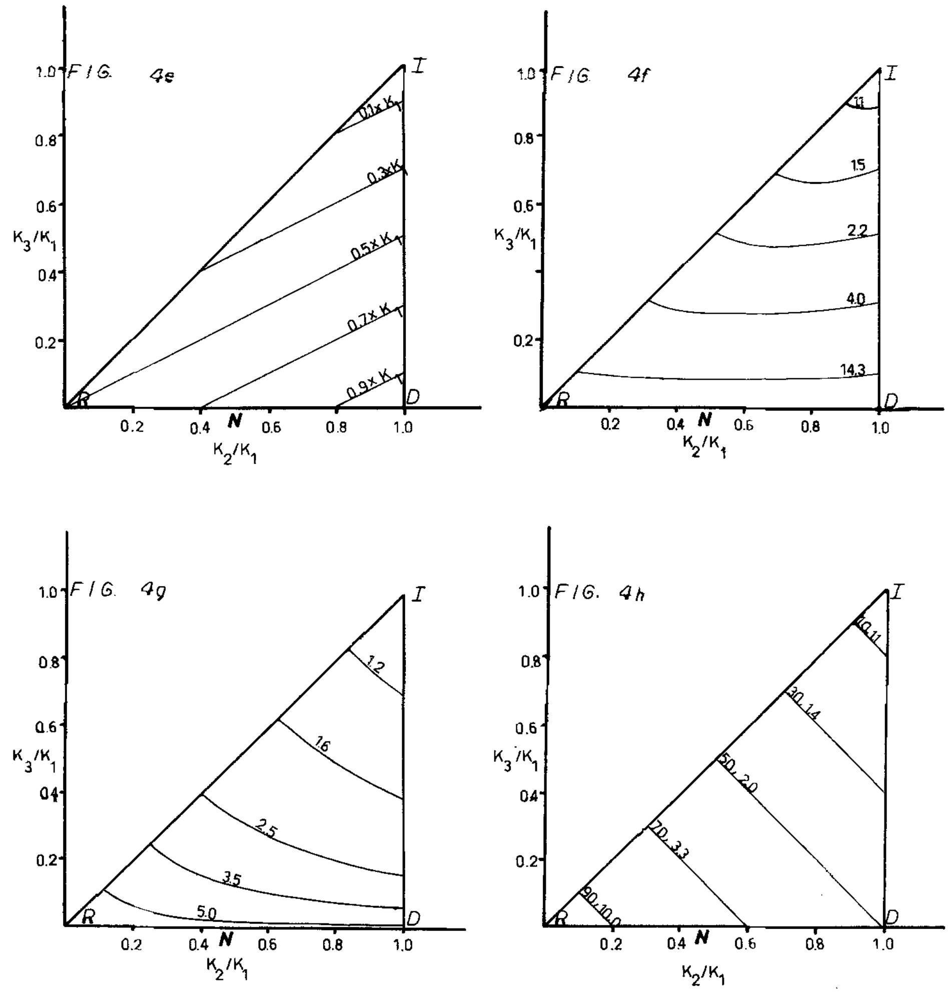
Degree of Anisotropy

Theoretical Aspects

Using the same approach as that in the preceding section, families of lines defined by each parameter in Table 2 can be found; results are shown in Figure 4. It is important to mention that two parameters that were originally proposed as quantifying the shape of the susceptibility tensor have been included in Table 2 because they generate families of curves that intersect both segments *IR* and *ID*, as explained before.



Figures 4(a–d)



Figures 4(e–h)

Figure 4
Families of lines representing different categories of anisotropy according to the parameters listed in Table 2. Numbers on the lines are the required values of those parameters to generate the corresponding line. a) Parameters 1 and 2, b) 3 and 4, c) 5, d) 6, e) 7, f) 8, g) 9 and h) 10 and 11.

The similitudes between the resulting eight families of lines are not as clear as in the case of the shape parameters, even restricting our attention to some region above some critical value of the ratio k_3/k_1. However, at least in an approximate way the four groups (A1–A4) of parameters shown in Table 2 can be identified, although it should be noted that some families of lines are closer to others near the isotropic point, while far from this point they become progressively more similar to a third family of curves. Thus, in this type of parameters, the similitudes between them will depend on how far from the isotropic point we are.

Empirical Aspects

Use of the profile of samples described above was also used to test the theoretical predictions of similitude between parameters. Surprisingly, all the parameters of Table 2 produced profiles which are almost completely identical to each other (Fig. 5), indicating that all of them could be regarded as completely equivalent for most practical purposes, although a slight difference in the spacing between samples is observed. The similitude of the profiles seems to be related with the closeness to the isotropic point characteristic of all the specimens used; if specimens farther from this point were sometime available, the difference between profiles would be more marked.

It is interesting to note that the degree of anisotropy of the specimens in the profile seemed to bear some connection with the different lithologies within it. Lava flows and sedimentary rocks have the lowest degree of anisotropy, the Koolau dykes and half of the samples of the Whin sill are slightly more anisotropic and the peridotite samples have the highest degree of anisotropy relative to the remaining samples. Although it is not suggested that this is a universal relationship that will

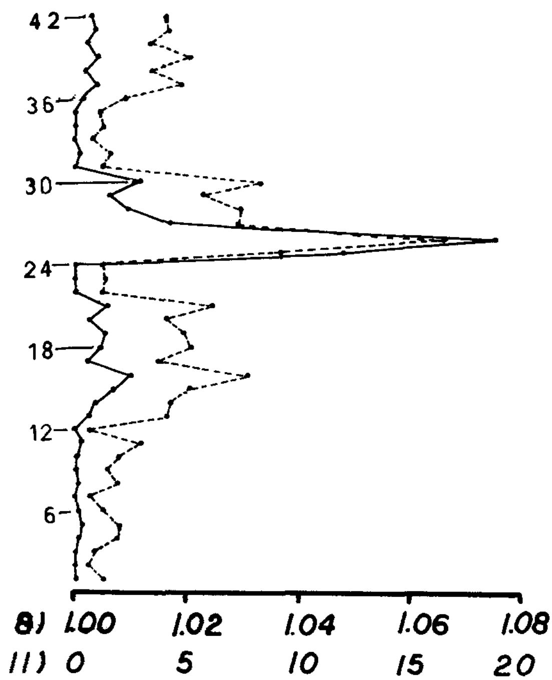


Figure 5
Values of the parameters of Table 2 calculated for the profile constructed with samples of different lithologies. The different parameters lead to profiles that were contained between those two shown, which correspond to the A3 group (solid line) and A4 group (dotted line; only scale for parameter 11 is shown). Vertical numbers mark the boundary of two different lithologies as explained in the text.

be found in every case, it is important to note that the distinction is somewhat clearer by using parameters of the A4 group and less evident with those in the A3 group.

Additional aspects regarding the range of allowed numerical values are important factors that must also be considered before selecting a given parameter in this class. Some workers seem to have a tendency to express the degree of anisotropy in terms of a percentage, and in this regard it seems more reasonable to express the results using a parameter that only allows variations between 0 and 100%, in which case parameters 2, 7 (normalized to k_1) and 11 are the most natural options. In any case, the two most important results in this section are: 1) some parameters introduced in a different context can be more closely related to those parameters quantifying the degree of anisotropy than to their original purpose, and 2) given the small departures from the isotropic case that are to be found in most specimens of rocks, no large differences are to be expected when any two different parameters from Table 2 are used.

Summary

Comparison of 28 susceptibility parameters was made in a general context leading to the establishment of equivalences among many of them. The identification of most foliation and lineation parameters as special cases of shape parameters suggests that only two classes of parameters (shape and degree of anisotropy) are necessary to characterize measurements of AMS, instead of the traditional four (shape, foliation, lineation and degree of anisotropy). Perhaps of major consequence is the suggestion that it is not possible to resolve the effects of a magnetic foliation and lineation from each other using AMS measurements alone, which makes this technique different from other structural methods. Certainly, by plotting any parameter marked with one asterisk in Table 1 against any parameter marked with two asterisks in the same Table, an apparent separation of both quantities would be obtained. However, as was shown in the discussion of the shape parameters, it is only the asymmetric range of numerical values which produces the "resolution" of the corresponding magnetic fabric, and therefore, the separation between lineated and foliated fabrics would be more an artifact of the parameters than a physically significant result.

Despite the usual assumption that parameters belonging to the same class would not yield markedly different results in a qualitative sense, it was shown that not all the parameters within a given class are completely equivalent, and that although the main difference seems to be on the range of numerical values, this may lead to significant differences in the interpretation of results, i.e., the use of different parameters may enhance or preclude the identification of some specific characteristic displayed by the rock. In an extreme case, two parameters that were originally proposed as quantifying the magnetic fabric of a rock have been shown to behave, in a mathematical context, more closely to parameters measuring the degree of anisotropy, which clearly indicates that the selection of parameters is not as straightforward as thought before.

From the 11 degrees of anisotropy parameters examined in this work, no appreciable difference was detected in a general sense, although some displayed higher sensibility to changes in the degree of anisotropy associated with some specimens.

Finally, it seems important to remark that from the mathematical equivalences between parameters established in this work it is not possible to identify the single parameter that is best in characterizing AMS measurements. At most, it may be suggested that two parameters from Table 1 (one each from groups S1 and S2, excluding those with asterisks) should always be used, although differences between the resulting magnetic fabrics may be negligible in some instances. In relation to the parameters of Table 2 it may seem reasonable to compare results obtained by using any one parameter from groups A3 and A4, although due to the small anisotropies that are usually observed in rocks, all parameters in this table may be assumed as equivalent.

In conclusion, by using a mathematical approach independent of the definition of concepts such as magnetic foliation, magnetic lineation or degree of anisotropy, a series of guidelines have been suggested that can provide the necessary framework to select suitable parameters for the presentation of measurements of AMS. Hopefully, the application of the criteria proposed here will open the way to a more fruitful interpretation of AMS measurements, especially in igneous rocks where the departures from the isotropic case are extremely small, and in which the magnitude of the principal susceptibilities have customarily played a minor role.

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