# MAGMA FLOW DIRECTIONS IN THE PONTA GROSSA DYKE SWARM (BRAZIL), DETERMINED FROM ANISOTROPY OF MAGNETIC SUSCEPTIBILITY

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## INTRODUCTION

Magma flow direction has been the subject of many investigations in recent years and evidences of considerable horizontal movement of the magma inside fissures has been pointed out by many authors (e.g. Park et al., 1988; Rickwood, 1990; Knight & Walker, 1988; Ernest, 1990). Magma flow directions given by internal features of dykes may help to establish the location of magma sources in areas where they are not obvious. However the phenomenon, sometimes, can not be observed directly because flow-fabric in mafic dykes may be only weakly present and therefore difficult to map petrographically or in the field. In this case, the determination of the axes of the magnetic susceptibility anisotropy may be very helpful.

The anisotropy of magnetic susceptibility (AMS) shows the directional variation in the magnetization of iron oxides present in a rock (McDonald & Ellwood, 1987; Hrouda, 1982). This variation can be geometrically represented by a triaxial ellipsoid whose principal axes define the orientations and magnitude of the maximum ($K_1$), intermediate ($K_2$) and minimum ($K_3$) susceptibilities. The AMS is sensitive to only a few percent shape anisotropy and is therefore a valuable tool for studying the flow fabric of mafic dykes.

In this paper the AMS technic has been applied in order to investigate the flow directions of the magma that filled the Ponta Grossa fractures.

## THE PONTA GROSSA ARCH DYKES

One of the most expressive Phanerozic mafic dyke swarm in Brazil occur in the so called Ponta Grossa Arch (Oliveira & Montes, 1984; Sial et al., 1987). The dykes intrude the Paleozoic sediments of the Paraná Basin as well as the Pre-cambrian rocks of the crystaline basement (Fig. 1). They are formed by andesi-basalt tholeiites and rare acid rocks and their widths vary from tens to hundreds of meters. Five groups of structural directions were detected; two of them are NW (N40-60W, N10-20W) and are predominant; two are NE (N30-45E, N60-75E) and one, less expressive, is E-W

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(Raposo & Ernesto, 1991).

## RESULTS AND CONCLUSIONS

For the measurement of the AMS a Molspin equipment was used. After the application of some reliability criteria data from 100 dykes, out of the 126 initially sampled, were considered reliable. The maximum anisotropy direction ($K_1$) represents the flow direction and is defined by the declination and inclination angles. The declination corresponds to the azimuth of the dyke (within an error that for the majority of the Ponta Grossa dykes is at most $25^{o}$) and the inclination (I) is the angle between the axis and the horizontal plane.

Figure 2 is the equal-area projection of the $K_1$ axis in the lower hemisphere. In this figure data from the areas of Fartura, Sapopema/Telêmaco Borba, Guapiara and Curitiba have been discriminated by different symbols. Five categories of flow were defined: horizontal ($0^{o} < I < 10^{o}$), subhorizontal ($10^{o} < I < 20^{o}$), inclined ($20^{o} < I < 50^{o}$), very inclined ($50^{o} < I < 70^{o}$) and vertical ($70^{o} < I < 90^{o}$). The majority of the dykes (57%) showed horizontal or subhorizontal flow, 26% showed inclined flow, 11% very inclined and only 6% presented vertical flow.

In general, each of the considered areas exhibits all kinds of flow (from horizontal to vertical) although the vertical flow was only noticed (6 dykes) in the Sapopema/Telêmaco Borba and Curitiba areas. On the other hand most of the dykes showing inclined and very inclined fluxes occur in the Guapiara and Curitiba areas (eastern portion of the arch), suggesting that these areas could be closer to a probable magma source. This fact however does not exclude the existence of other sources inside the Ponta Grossa Arch.

From Figure 3 it is clear that all systems of dykes, no matter their structural directions, could be filled by flows within any of the inclination ranges. However, the vertical and very inclined flows are found mainly in the NW directions whereas the E-W fractures were filled preferentially by subhorizontal flows.

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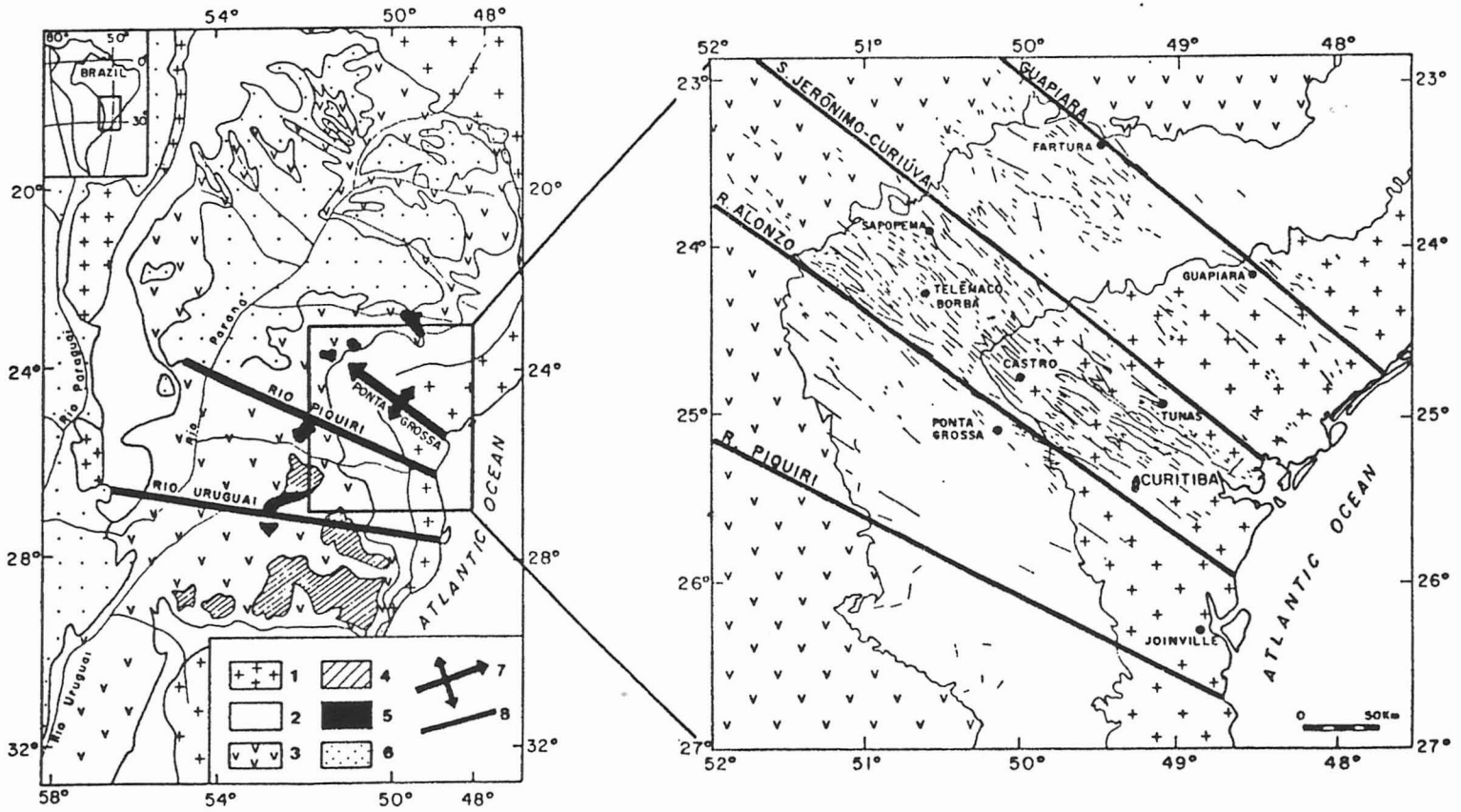


Figure 1 - Generalized geological sketch map of Paraná Basin, showing Ponta Grossa Arch: 1.crystaline basement; 2.pre-volcanic sediments (mainly paleozoic); 3.basic to intermediate flood volcanics of Fm. Serra Geral; 4.acid stratoid lava flows (Palmas type) of Fm. Serra Geral; 5.acid stratoid lava flows (Chapecó type of Fm. Serra Geral; 6. pos-volcanic sediments (mainly Upper Cretaceos); 7.arc-type structure; 8.tectonic and/or magnetic lineaments.

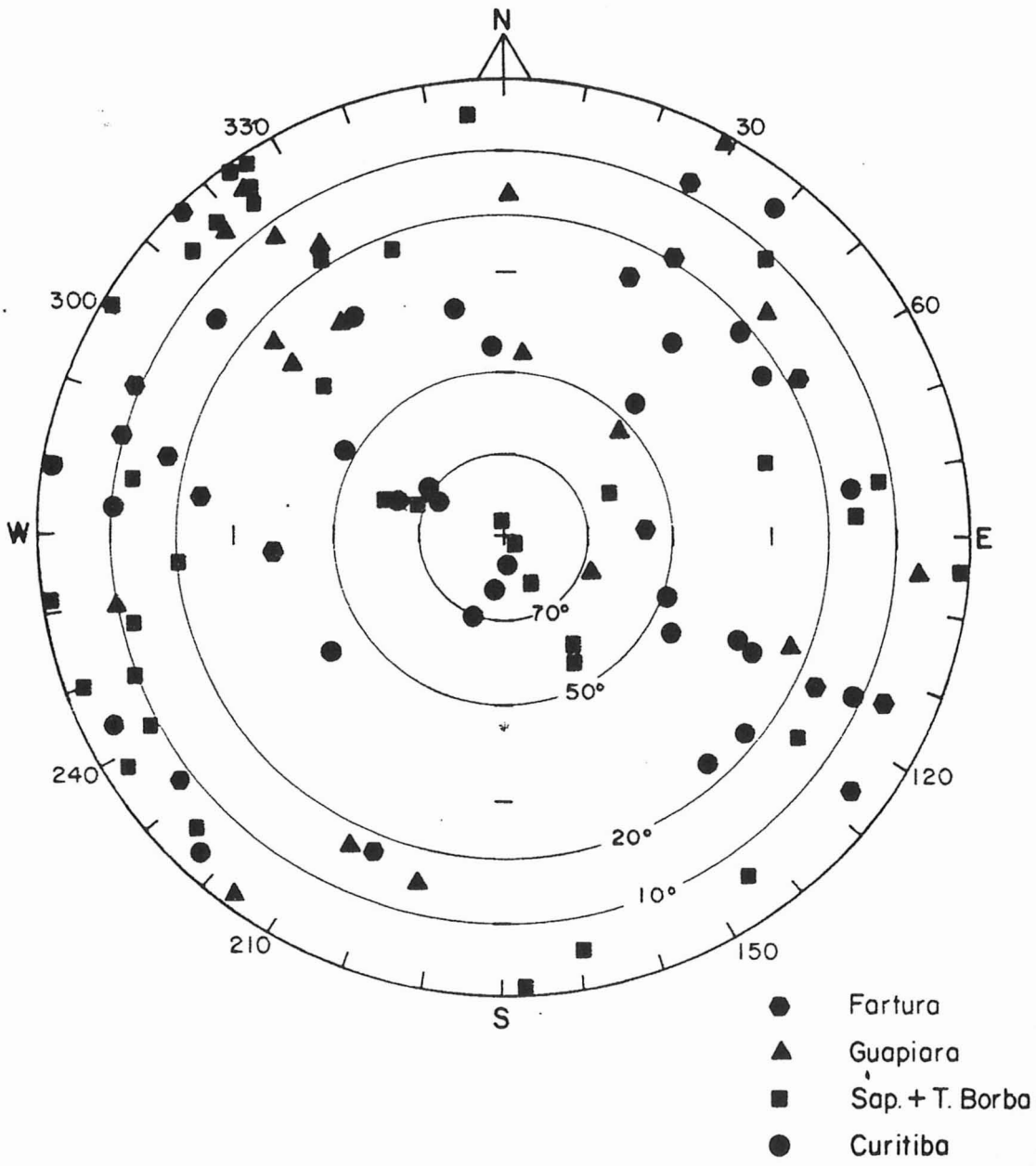


Figure 2 - Equal-area projection in the lower hemisphere of the maximum anisotropy axis ($K_1$) for the different areas of the Ponta Grossa dyke swarm.

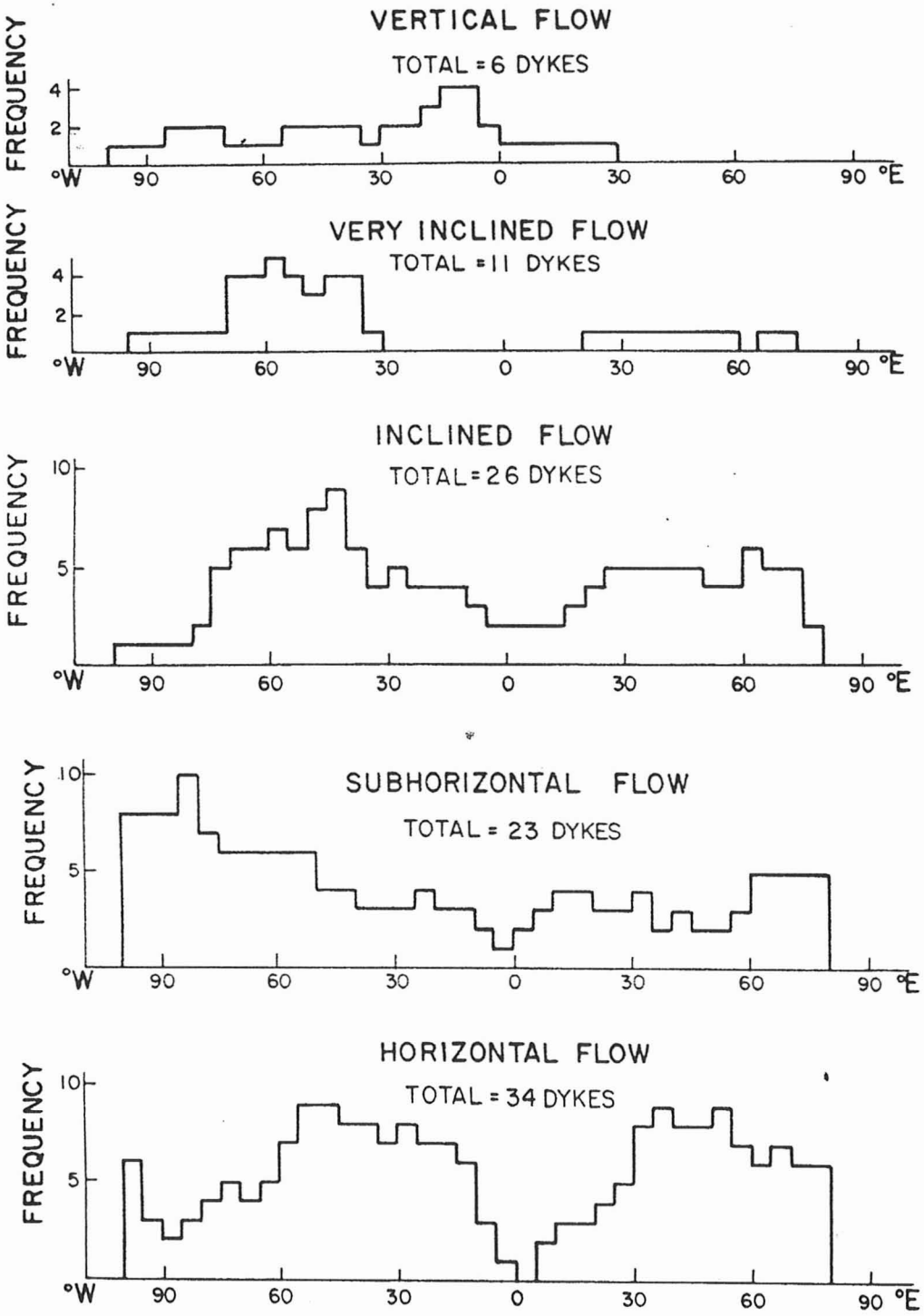


**Figure 3** - Frequency diagram showing the relationship between the structural direction of the dykes and the magma flow categories.