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Construction of Structural Geological Model using Monte Carlo Simulation

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Abstract

To optimize the prediction of structural geological conditions in the underground as of data collected at the surface, due to the usual great uncertainties involved, we discuss new perspectives for the construction of structural geological models, bearing in mind the common doubts involved and their implications in the safety of infrastructure works, mining, etc. This paper presents a statistical simulation applied to structural geological measures (*dip-dip direction*) obtained from schists during the design and construction of civil works through a correlation between surface data with different depth levels. Angular structural geological measures of joints and foliations converted in direction cosines were subjected to the PERMANOVA test to verify the amplitude of differences at different depth levels. The asymptotic results allowed to determine regions of confidence built around centroids through statistical simulation, allowable consistency was considered in regions where the differences in the simulated values were small enough from a practical point of view, taking into account that the difference between joint structures and foliation structures is smaller in the former. The foliation is a characteristic structure of rock deformation just like the joints.

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1. Introduction

Seeking to understand the interaction between human activity and geological environment, aiming at positive or negative previsions in a project, and it is need of eventual prevention is the main focus of most of Geology Applied to Engineering, be it civil construction, mining, oil or environment (Hasui & Mioto 1992, Pastore *et al* 1998, Sadowski, 2014, among others). The correct prediction of structural geology involving the spatial dispositions of contacts between different lithologies and their respective discontinuities are one of the main geological determinants of the stability of large foundations and excavations, open-cast or underground. All stability analyzes carried out in rock engineering are subject to uncertainties thus generating geological risks, these risks may cause the execution of the work not to meet the pre-established requirements, causing financial losses and risks to human life, as well as serious problems of environmental issues.

Geological risk assessment in places of difficult viewing and access, such as underground conditions, aims to minimize the inherent faults in the data collection or exploration of the conditions of the rock masses in-depth, reducing errors is important to the safety of employees during the work, the control of the planned expenses, as well as the durability of the civil works, promoting social, financial and environmental safety. The mistake in the predictability is related to the number of uncertainties that are contained in several stages of the works, which are inseparable in geotechnics (Costa, 2005), because of this, Ang & Tang (2007) highlight the importance of identifying them.

In general, geological risk analyses are performed through deterministic analysis of the geotechnical parameters. These methods frequently do not quantitatively consider the randomness and variability of the parameters involved in the project, making it difficult to identity uncertainties (Hoek et al, 1997). In this case, the analysis does not demonstrate exactly the degree of predictability of the underground conditions of the works, in other words, the identification of the error percentage in the geological model. In the last years, there has been a great interest in incorporating methodologies that allow estimating the uncertainty associated with geotechnical studies, as is the case with probabilistic methods or statistical simulation (Ge *et al.,* (2011); Montoya & Assis (2011b); Hudson and Feng, (2015)).

The main proposal of the present study is to use applied statistical analyses, to structural geological data, aiming to optimize the predictions of the geological conditions in depth. The specific goals involve the following topics: i) compilation of geological and structural data of the study area, ii) transformation of directional data into linear data for descriptive statistical analysis, iii) correlation between surface data and depth data, iv) construction of the structural geological models using statistical simulation with the use of the Monte Carlo technique.

This study is applied in a practical example in order to try to answer the question: *"Is it possible to know the data in depth using simulation?*" In the search for an appropriate answer to this question, we use the Monte Carlo simulation, to better understand the correlation between the data collected in the field, on the surface, with those existing in-depth, which is difficult to predict and/or access.

2. Geological Setting

The structural geological data were obtained during the construction of a hydroelectric dam, in the Southeast of Brazil, in the Minas Gerais state (Fig. 1a). This area is composed of complex geology, the main tectonic unit is simplified in figure 1b with identification of the collection site. The topography of this area is smooth, being dissected by several streams along the Araguari river valley, with basement outcrops belong to the Brasilia belt (Fig.1b), this unit is composed predominantly of metasediments rocks of the Araxá Group, local granitoid rocks and gneiss from the Maratá Complex.

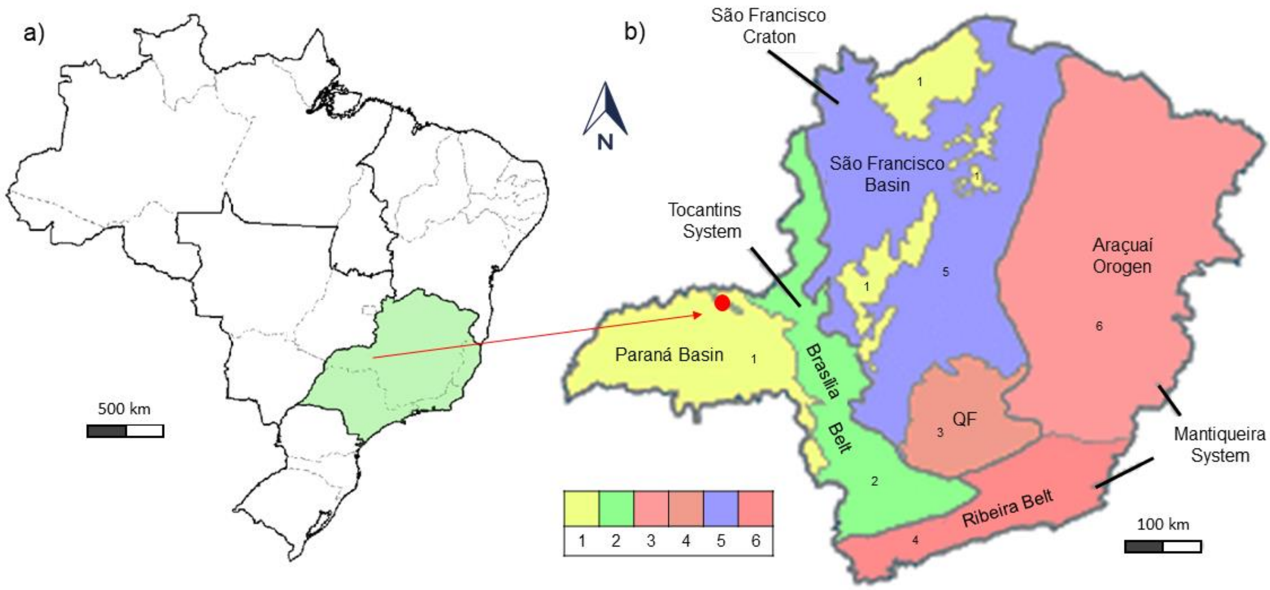


Fig. 1 a) Boundary map of Brazilian Regions with a green highlight on the Southeast Region b) Minas Gerais State map shows the compartmentalization of geotectonic units identified by the number (1) Paraná Basin; (2) Brasilia belt; (3) Quadrilátero Ferrífero unit (4) Ribeira belt (5) São Francisco Craton and São Francisco Basin and (6) Araçuaí belt, and the red dot identifying the data collection location

The dam is situated in the hydrographic basin of Araguari river (Fig.2b) in the realm of schists belonging to the Araxá Group, strongly foliated, with tectonic contacts (shear zones) with the local gneisses, causing parallelism in both gneissic banding and granitic foliation (Pacheco *et al.,* 2017). The Maratá Complex represents a narrow strip of granitoid rocks interlayered with the Araxá metasediments and is composed of augen-gneiss and porphyritic meta-granite with quartz, potassium feldspar, biotite and muscovite, frequently carrying a mylonitic texture (Pimentel, 2016; Pacheco *et al.*, 2017)

(Fig.2c). Amphibolites interspersed in the metasediments of the Araxá Schists were interpreted as remnants of a mafic-ultramafic magmatism (Strieder & Nilson, 1992; Pimentel *et al*., 1999); additionally, there are quartzite and micaceous mica schists, included calcschists, chlorite-moscovite schist, garnet biotite schist, staurolite schist and feldspar schists, with few paragneiss and marble intercalations. (Pimentel, 2016). The presence of anastomosed foliation, intra-folial folds, three generations of metamorphic foliations, stretching, mineral lineations, and all these structures denote the complex tectonic evolution of these metasediments (Valeriano, 1993).

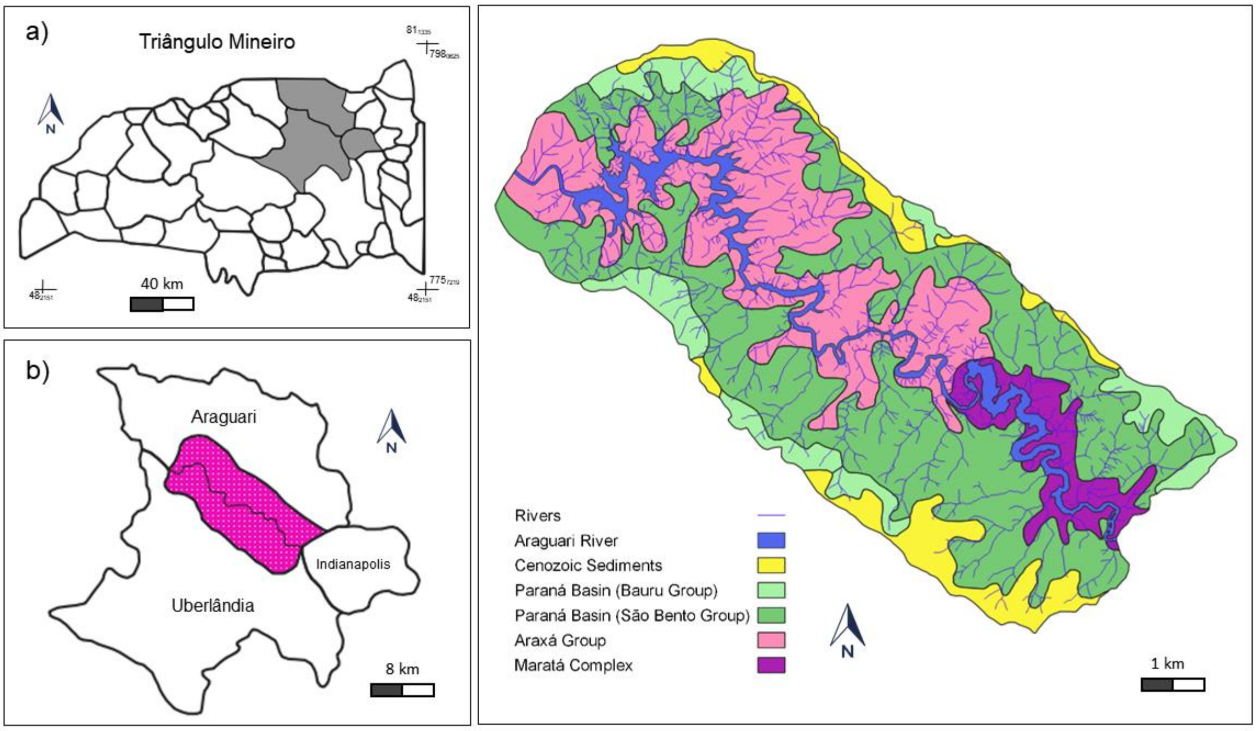


Fig. 2 a) Map of the municipalities of the southwest of the Minas Gerais State. In gray the municipalities of Araguari, Uberlandia and Indianapolis b) Localization of the hydrographic basin of the Araguari river c) Geological map restricted to the region of the Araguari river basin with the main units in this area. Schist of the Araxá Group (pink color) and gneiss of Maratá Complex outcrop along the riversides

Araxá schists was formed by the metamorphism of sedimentary rocks that occurred during the compressive phase of the Neoproterozoic orogeny (PanAfrican/Brasilian), of which, two phases of progressive deformation can be individualized in a simple shear regime. The first deformation phase is responsible for the development of the regional foliation with N-S direction dipping approximately 50° to west, this foliation is the axial plane of isoclinal folds. The second deformation phase corresponds to crenulation formed by small folds whose axial planes are oriented preferably NW-SE/sub-vertical. This structure deforms the regional foliation of the N-S direction with plunge to east, and this change in the dip direction could be responsible for the dispersion of the foliation diagram (Pacheco *et al*, 2017).

3. Descriptive Analyses of Structural Geological Data

A sampling of the structural geological data was performed in two different ways: i) first a set of the measurement were obtained during the surface mapping, resulting in 396 measures, and ii) during the construction, 953 new additional data were gathered in the built slope, the headrace tunnel and appurtenant dam structures (Fig. 3).

All measured data are in a dip and dip-direction notation, divided between two different structures, foliation and joints. The foliation refers to repetitive and different compositional layering in the metamorphic rocks and, the joints are discontinuities formed as a result of regional stress after the rock consolidation.

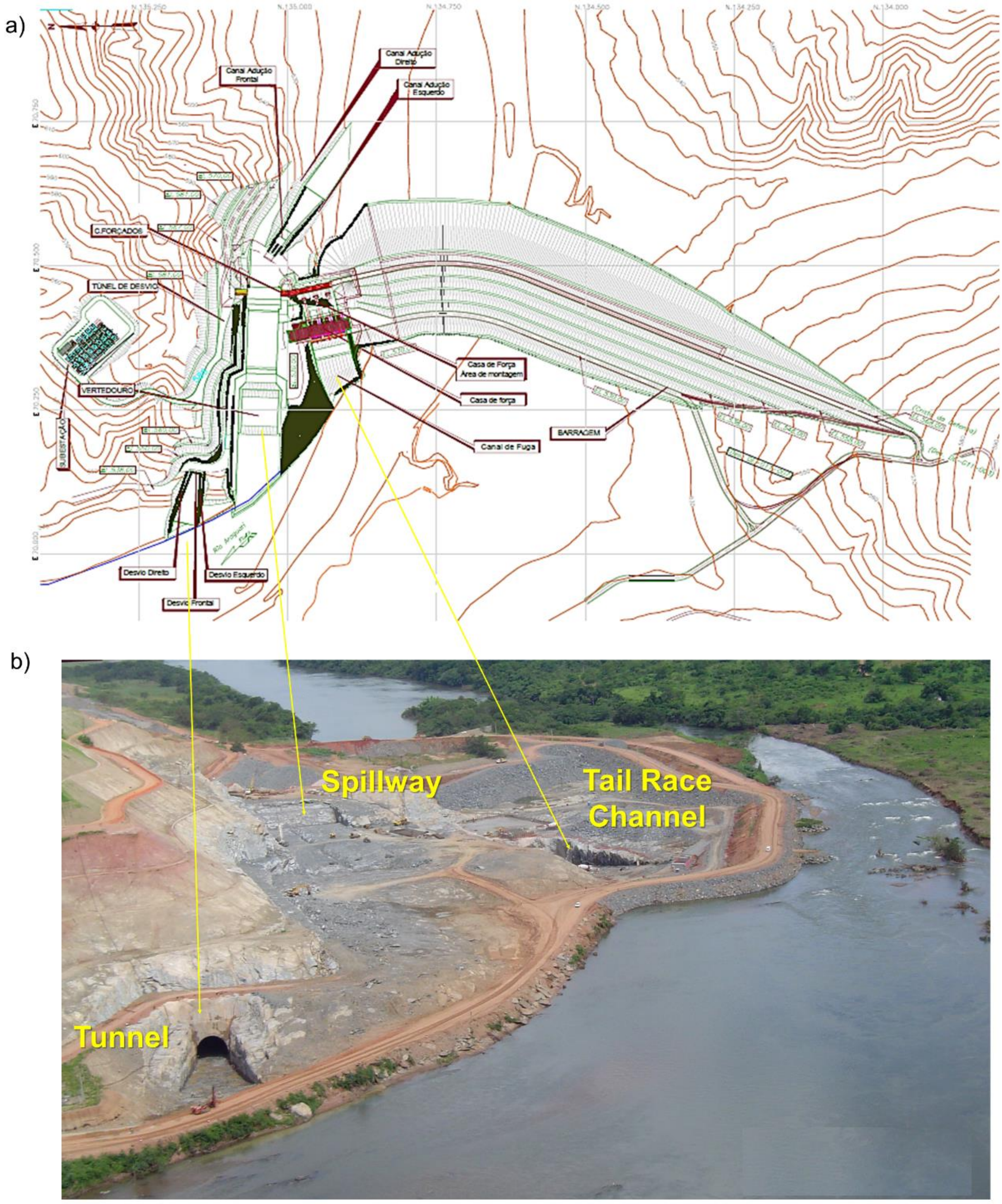


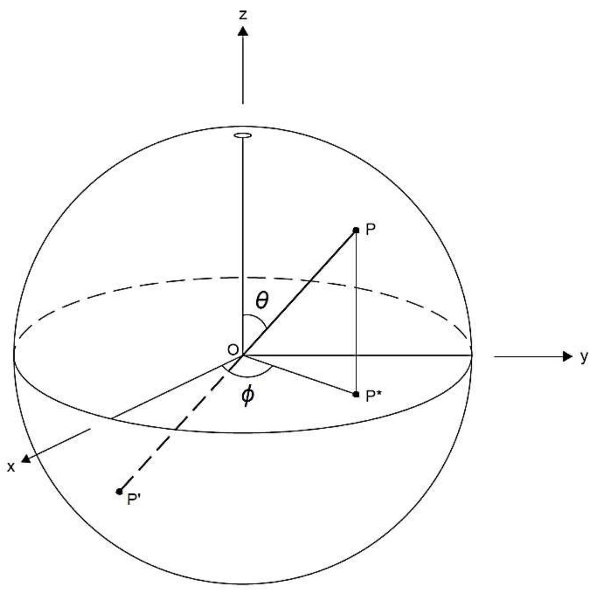
Fig. 3 a) Illustration of the dam structure in the topographic map b) Photo with the identification of data sampling sites

In order to organize the statistical analyses, the structural data were separated into their different types, place of measurement, surface and depth intervals (Tab.1). All data are present in supplementary materials 1, which contains the level where the measure was taken, type of structure (foliation and joints), and the transformation between dip dip-direction to direction cosines.

Table 1 Distribution of data collected

Elevation	Depth	Number of measures	Joints	Foliations
surface	0 m	396	233	163
558 - 540	0 - 18 m	61	39	22
540 - 530	18 - 30 m	115	79	36
530 - 520	30 - 40 m	177	145	32
tunnel	50 m	314	197	117
520 - 500	50 - 60 m	286	211	75

To perform the statistical analysis, both at the surface and depth, all data were converted into direction cosines. The transformation of dip and dip-direction measures into direction cosines X, Y, Z were made using the usual spherical coordinate systems (Mardia, 1972 and Fischer *et al.,* 1993) with lower hemisphere (Fig.4). This type of transformation is important to enable the simulation of the statistical model. The y position corresponds north direction, the dip value is transformed into θ by equation (3.1) and dip-direction value into ϕ by means of the equation (3.2)



$$\theta = 90° - \text{dip} \quad (3.1)$$

$$\phi = 360° - (\text{dipdirection} - 90°) \quad (3.2)$$

Fig. 4 Ilustration of the position coordinates used to calculate the direction cosines, the θ = latitude and ϕ = longitude, P represent polar projetion of data (Fisher et al 1993).

3.1 Foliation and Joints

After the transformation of the measurements, it is possible to observe the spatial distribution of all the data *dip-dip-direction* that were transformed in direction cosines (Fig.5a), where the red dots represent the direction cosines data that were obtained in-depth, the blue dots show the direction cosines data collected in the surface, each point represent one measure. The representation using stereographic projection of all these dada that were transformed in direction cosines, including foliation and joints planes, shows the spatial distribution of all the planes (Fig. 5b), however, it is not possible to distinguish between foliation and joints. To identify the statistical significance of each planar structure, it is necessary to proceed with an analysis separately. We begin analyzing the direction cosines of the foliation and joints differently, and it allows to visualize the direction cosines obtained for the foliation measures, it is noted that there is a greater homogeneity in the spatial distribution, both in surface and in-depth (Fig.5c), which can be seen by the representation through stereographic projection that shows a single main concentration, with *dip-dip-direction* 49/277 (Fig.5d).

The representation of direction cosines for joint measures exhibit two principal concentrations, the red dots, representing depth joints, which have a higher frequency than blue dots, expressing surface joints (Fig.5e). The projection of the 904 joint data, highlights four different joint systems, the most significant concentration named *J1,* presents the *dip-dip-direction* 87/251. The *J2* set (52/281) has characteristic the parallelism (sub parallelism) with the foliation planes. Two other sets, statistically less important, *J3* (85/344) and *J4* (30/120) complete the four joint systems identified in the area (Fig.5f). The correspondence between the representation of data and main planes, cannot be distinguished into projection diagrams.

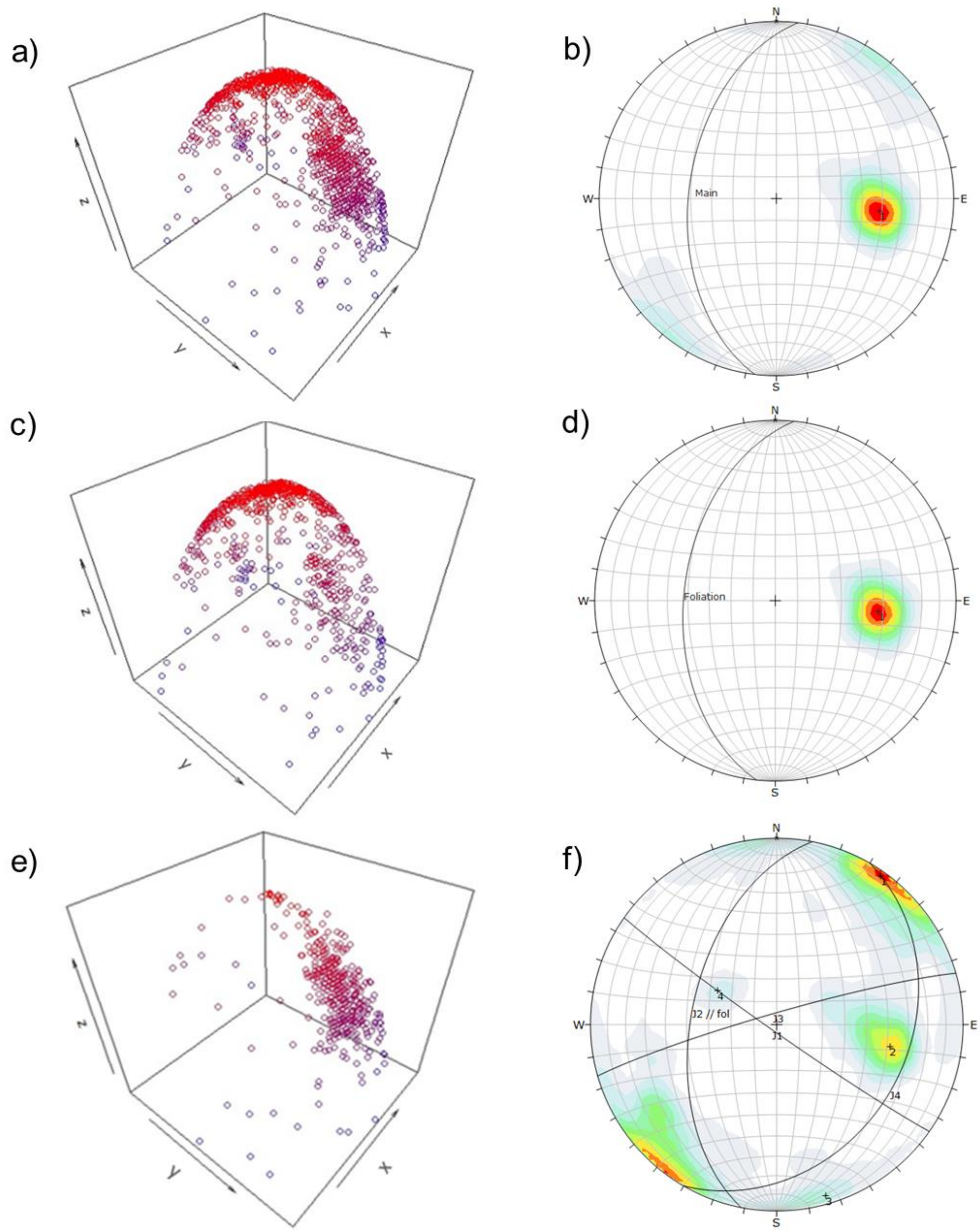


Fig. 5 Correlation between direction cosines and stereographic projections in different situations a) The projection of direction cosines of all the 1349 measurements (foliation and joint at surface and depth), where the red and blue dots represent, respectively, the depth and surface data b) Stereographic projection, lower hemisphere, of the totality of data showing the average value of 49/277 (dip dip-direction) c) Spatial representation of direction cosines

related to foliation (445 measurements) d) Using stereographic projection the mean value of the foliation is 48/276 (dip and dip-direction) e) Direction cosines diagram using 904 data of joints f) Stereographic projection of the joints highlights four distinct sets: J1 (88/215), J2 (54/282), J3 (85/344) and J4 (30/120) using dip dip-direction notation

For the correlation between surface - depth data and to achieve a 3D structural model, it is necessary to evaluate the statistical distribution of the foliation and joints for different depth levels. The analysis, for joint and foliation planes, was performed in three different depth intervals, as follows: we highlight the projections of direction cosines from the surface to 15 meter of depth (Fig.6a), then between 15 and 45 meters deep (Fig. 6b), and finally the stretch between 45 and 60 meters (Fig.6c). The respective representations of stereographic projections, in each level, are illustrated in figures 6d, 6e and 6f, which were evaluated separately, show a good similarity between the three distinct depths, with a principal direction average N-S dipping to West. The larger quantity of measurements in the last stretch was due to the greater amount of fractures present in the tunnel.

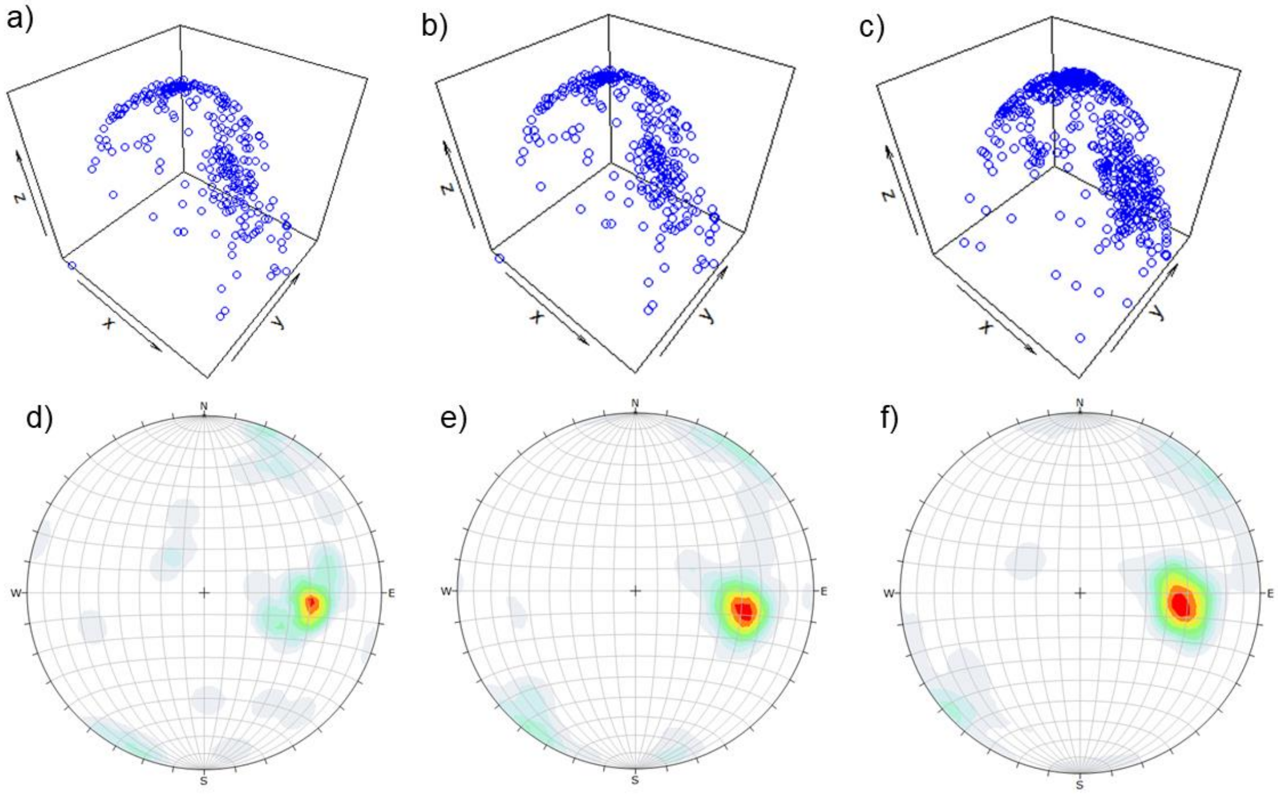


Fig. 6 Spatial representation of direction cosines and stereographic projection of the foliation and joints orientations at the three different levels of depth a) The direction cosines graphic for the measure of the first level of 0 to 15 meter of depth, with 431 measures b) The direction cosines for measures of the second level of 15 to 45 meter of depth, with 319 measures c) The direction cosines for measures of the third level of 45 to 60 meter of depth, with 599 measures. The stereographic projections of the three different levels are very similar (d, e and f). The red point in each diagram represents the main concentration of the measurements (~NS/50W) with some scattered spots in gray

3.1.1 Foliation Data

The foliation represents the main structure in this area it direction is almost N-S with plunge 50° to West or approximately 50/270 in the dip/dip-direction notation (Fig.7). The stereographic projection of foliation measurements reveals the similarity in the two depth ranges, from 0 to 30 meters, was collected 90 measures, and between 31 to 60 meters, was collected 192 measures (Fig.7b and 7d). A large amount of measurements below 30 meters is due to the presence of the adduction tunnel at 50 meters of depth, complementing the data obtained on slopes, as previously mentioned. In the range of 0 to 30 meters deep, the director cosines show a dispersion (Fig.7a) due to a low quantity of data, however, the mean value corresponds to the main direction of the foliation. Similar conditions, but with a smaller dispersion, occur in the deepest levels (Fig.7c), although, the mean values still correspond to the orientation of the foliation (50/276) (Fig, 7b and 7d).

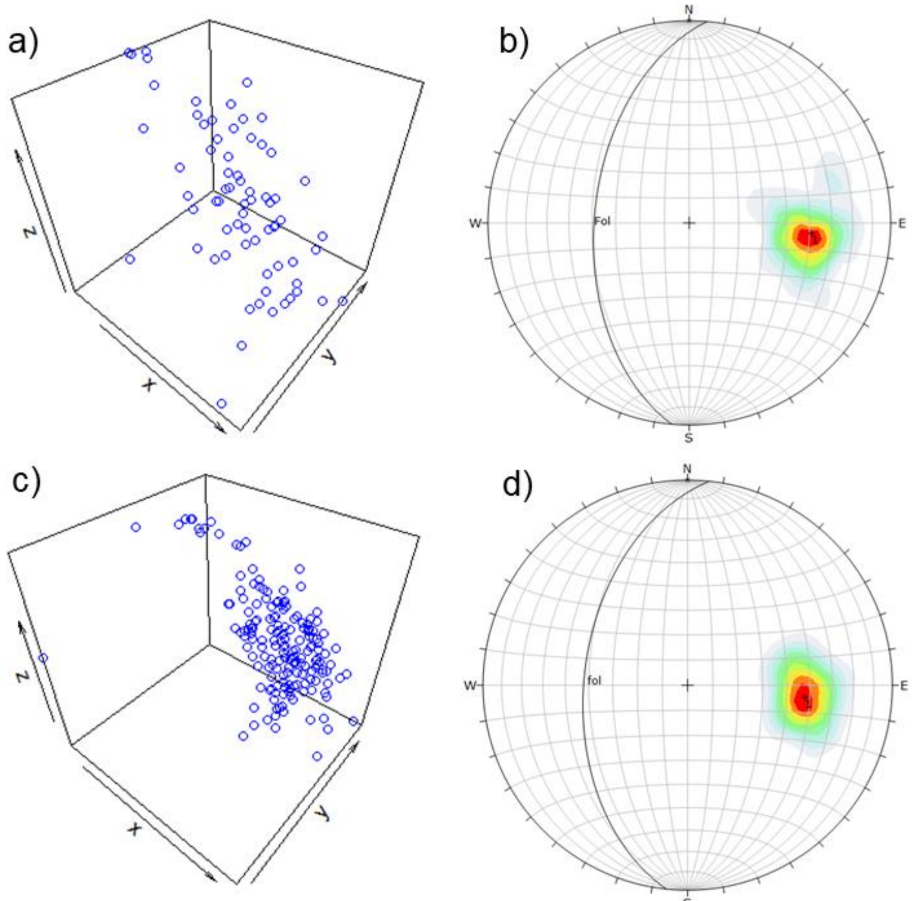


Fig. 7 The direction cosines and the stereographic projections for foliation measurements obtained from 0 to 40 meters of depth, respectively diagrams (a) and (b), with 90 measures. Statistically, the average value is 50/276. Diagrams c and d correspond to the same representations for the 41 to 60 meters of depth, with 192 measures. At both depth intervals, the mean value corresponds to the spatial orientation 49/276 (dip dip-direction notation)

3.1.2 Joint Data

Analyzing the joints measurements obtained for the stretch of 0 to 40 meters deep, it is possible to identify the J1 joint system as being the most statistically significant, with dip dip-direction 88/037 and, the J2 joint system, whose spatial distribution of it is direction cosines (Fig.8a) and stereographic projection (Fig.8b) show a sub-parallelism with the regional foliation J2//fol (53/283). Two other systems (J3 and J4) can observed in the diagram, is quantitatively less expressive, oriented, respectively to 86/175 and 56/077 (dip-dip direction notation) (Fig.8b), at this level there are 263 measures.

When it is observed the 41 to 60 meters level (Fig. 8c and 8d), is evident a new concentration named J4 that is opposite J2, and there are 211 measures at this level. If isolating the measurement obtained in the tunnel, there is a different configuration, it is possible to identify the only J1 in the direction cosine graphic (Fig. 8e), in the stereographic projection (Fig. 8f) there are all the joint direction systems with low concertation.

To visualize the two main structures (J1 and J2//foliation) a simple model (block diagram) was constructed with these data (Fig.9).

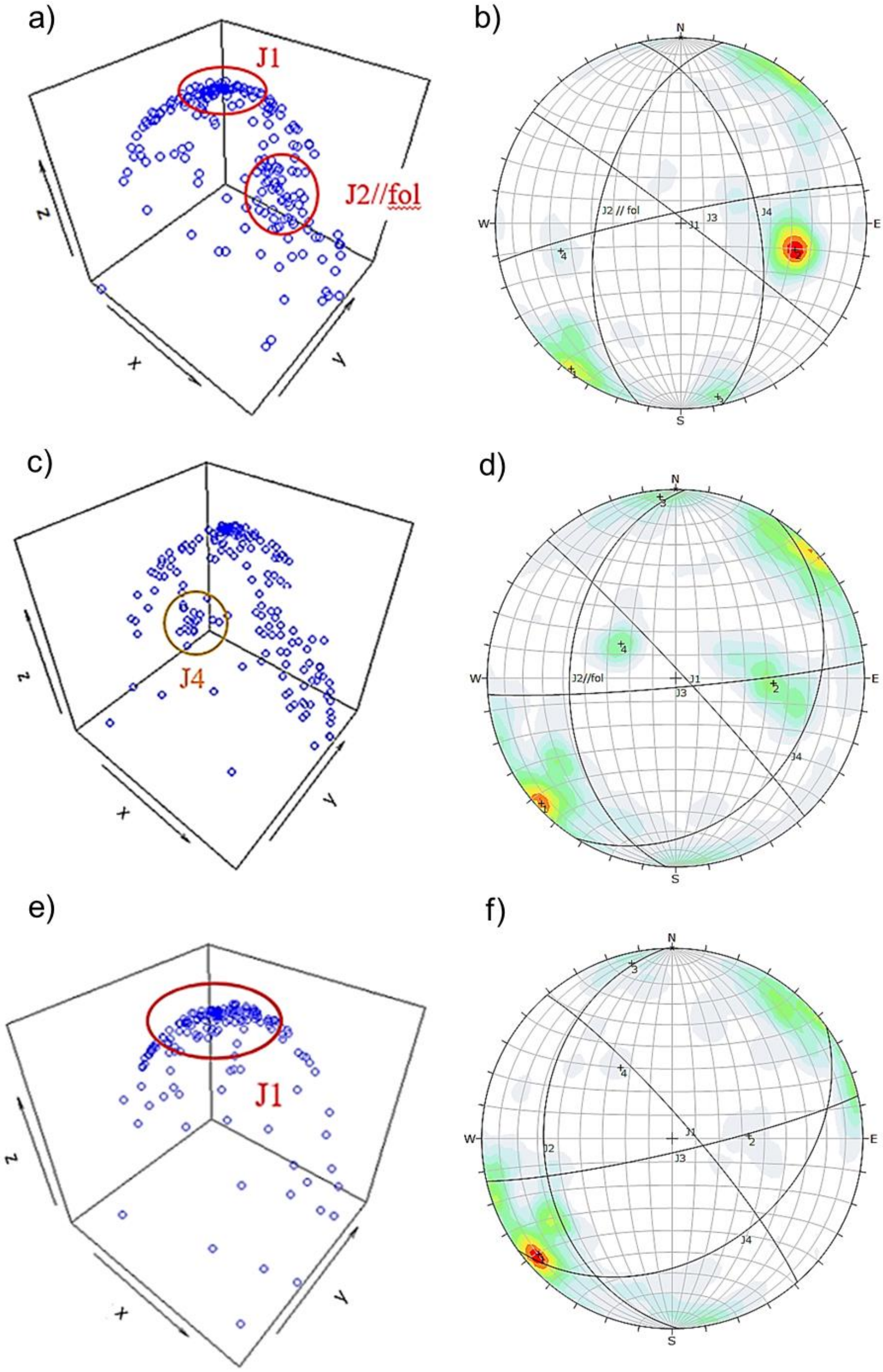


Fig. 8 Projections of the direction cosines regarding the measurements of joints obtained at the following depths: (a) 0 to 40 meters, showing the J1 and J2 system concentration; (c) 41 to 60 meters, highlighting the J4 concentration; (e) and 50 meters-depth in adduction tunnel, with a highlighting of J1 system. The respective stereographic projection diagrams for theses depths show the following joint systems: (b) J1 (88/037), J2//fol (53/283), J3 (85/355) and J4 (56/077); (d) J1 (87/047), J2//fol (43/273), J3 (85/175) and J4 (28/122) and (f) J1 (82/049), J2//fol (33/268), J3 (84/167) and J4 (32/144) (f), all the data are dip-dip direction notation

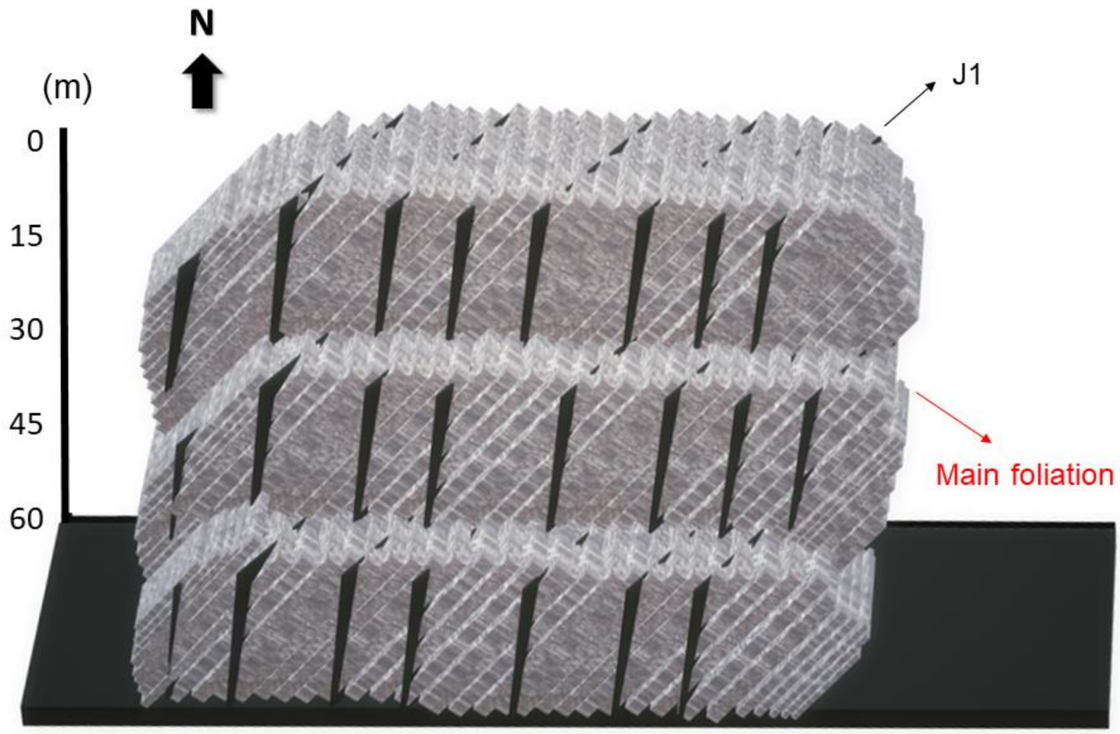


Fig. 9 Simplified block diagram showing the foliation, in the gray color, and the *J1* joint system in black color

4. Monte Carlo Simulation

After the descriptive analyses of structural geological data, it is important to understand the statistical distribution of data, since the Monte Carlo simulation consists of generating random numbers from of the real data with a known distribution. To analyze the data distribution, some techniques were used, initially, it was applied multivariate analysis of variance (MANOVA) model (Johnson and Wicher, 2007) for the direction cosines, considering the type of structure (foliation and joint) and level of depth as explanatory variables. However, the assumption of normality was not met, in others words, the data do not have a normal (Gaussian) distribution, even though homoscedasticity was verified, that in terms of statistics, homoscedasticity occurs when the variance in scores on one variable is somewhat similar at all the values of the other variable, therefore the variance of the error is constant.

Then was applied a permutational multivariate analysis of variance (PERMANOVA), which is a non-parametric model to test the hypothesis that the centroids of the groups are equal (Anderson, 2013), this analysis is used to compare groups of objects and test the null hypothesis that the centroids (confidence region – CR detailed below) and dispersion of the groups as defined by measure space are equivalent for all groups.

It was verified, statistically, the existence of an interaction effect between different depth levels and type of structure, tests of the depth effects were also performed for each structure, being, in both cases, significant with p-value > 0.01, this verification was done using the statistical significance analysis (equation 4.1)

$$p = 1 - \alpha \qquad (4.1)$$

The p-value is a result of interaction or significance, α is the level of significance, that is, the probability of the study rejecting the null hypothesis, given that the null hypothesis was assumed to be true, when the p-value is below 0.05, it means that the analysis confidence region has a low error.

Although the results of PERMANOVA indicate that there is a significant difference between the direction cosines of the surface and depth, from a statistical point of view, it does not give us the magnitude of this difference from a real situation, which it was understood as an incomplete result for what one wanted to investigate, this happens because the number of measures between surface and depth is different. Since it is known that p-value naturally decreases as the sample size increases (Krueger and Heck, 2019), it was decided to complement the problem from another perspective. In Mardia *et al* (1995), a version is presented for the central multivariate limit theorem, in which the average vector of a sequence of independent random vectors have a asymptotic multivariate normal distribution, once the sample is large, we then assume that this asymptotic approach is reasonable (Supplementary Material 2).

Using this result, it is possible to estimate a tridimensional parameter $\theta \in \mathbb{R}$ from the direction cosine sample (X, Y, Z) with the observed data we end up with a point estimate, which is the corresponding observed value of $\hat{\theta}$ (simulated data). We know that estimator $\hat{\theta}$ is a random variable (simulated data) and we often prefer to determine a *confidence region* (CR) for θ. A confidence region is a random subset of $\mathbb{R}$ (determinate by appropriate statistics) such that it is "confident", at a certain given level, that this region contain θ:

$$p\ (\theta\ \in\ \mathbb{R}) = 1 - \alpha \tag{4.2}$$

Confidence regions are particularly useful when a hypothesis H_0 on θ is rejected, due they eventually help in identifying which components of θ is responsible for rejection (Härdle and Simar, 2012) (Supplementary Material 3).

The equation 4.3 describe a confidence region for μ:

$$CR = \{\mu \in \mathbb{R} | (\mu - \bar{x})^{\top}\ S^{-1}(\mu - \bar{x}) \leq \frac{p}{n-p} F_{1-\alpha;p,n-p}\} \tag{4.3}$$

The μ value represent the ellipse of the simulation data. The CR is the interior of an iso distance ellipsoid in $\mathbb{R}$ centered at $\bar{x}$, with a scaling matrix S^{-1} and a distance constant $\frac{p}{n-p} F_{1-\alpha;\,p,n-p}$.

When p is large, ellipsoids are not easy to handle for practical purposes. Thus, we are interested in finding confidence intervals for μ1, μ2…μ for that simultaneous confidence on all the intervals reaches the desired level (1- α) (Härdle and Simar, 2012). With the described and calculated CR, it is possible to analyze the ellipses behavior obtained in the simulated data (Supplementary Material 4).

The graphic representation of confident ellipse for foliation and joints data shows that the black ellipse is representing the simulated surface data and red ellipse represents the simulated depth data, when the ellipse is larger it means that there is a variability of the data and them is greater in relation to centroid, this happens due quantity of measure. In the case of this example, there are more measures in depth than surface, then the ellipse that represents depth is smaller than surface ellipse in both analyzes graphs (Figs. 10 and 11).

To perform the correlation between surface and depth using the simulated data, the distance between the two ellipses is measured, when the ellipses are overlapping, it means that the simulation data is equal, if there is a distance between them, it means that there is a difference, in general we can obtain the magnitude of this difference with measure of Z axis. The Z direction cosine can range from 0 to 1, where 0 means that the both simulation data is equal, if the distance is 1, it means that the simulation data for surface is totally different to depth, in others words, if the distance is 0 we will have 0% difference between surface and depth, in the other hand, if we have the distance 1, we will have 100% difference between surface and depth simulation data, therefore, if the distance is 0.05 it is means that the difference between surface and depth simulation data is only 5%.

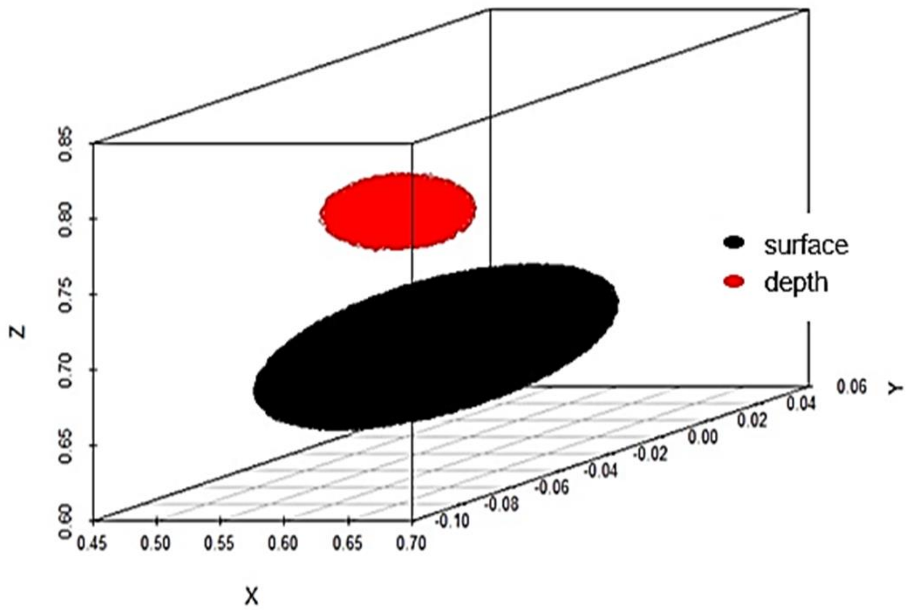


Fig. 10 Graphic representation of confidence ellipse of foliation data, the three axes correspond to direction cosines and red ellipse is a simulate data of depth and the black ellipse is a simulate data of surface

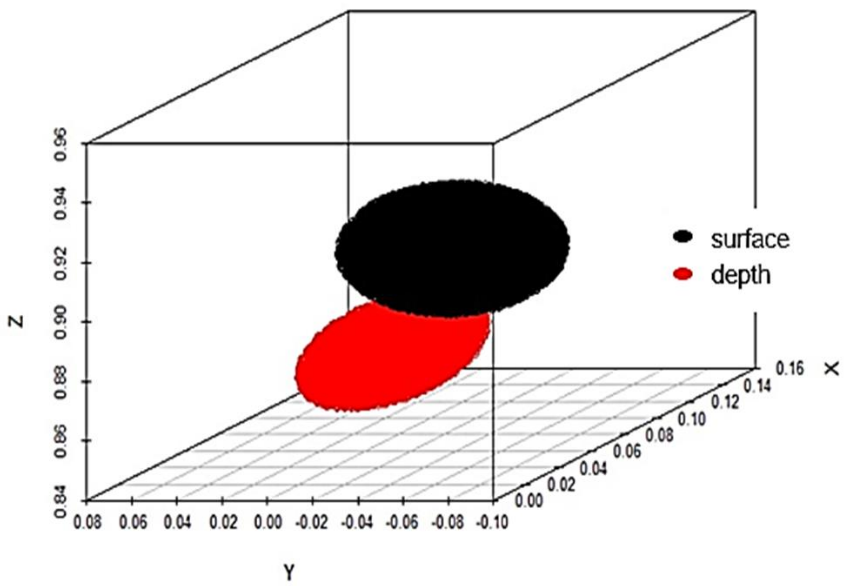


Fig. 11 Graphic representation of confidence ellipse of joints data, the three axes correspond to direction cosines and red ellipse is a simulate data of depth and the black ellipse is a simulate data of surface

The simulation for foliation data presents a difference between surface and depth data. This difference can be observed using the distance between the ellipses, in this case, distance is around 0,05 (direction cosines unit), but in terms of magnitude scale, this difference does not change the feature of foliation measure (Fig. 12). Therefore, there is a resemblance between surface and depth, if it considers that 0,04 – 0,05 for direction cosines Z means that the difference is around 4% then the simulation is representing the real data for the foliation data. For joint simulation (Fig.13), there is the similarity of the size of ellipse due to less variability in average values, the distance between ellipses, that means a difference with respect of surface and depth data, in magnitude scale, has 0,02 - 0,04 for direction cosines Z means that the difference is around 4%, thus it has the same situation for foliation.

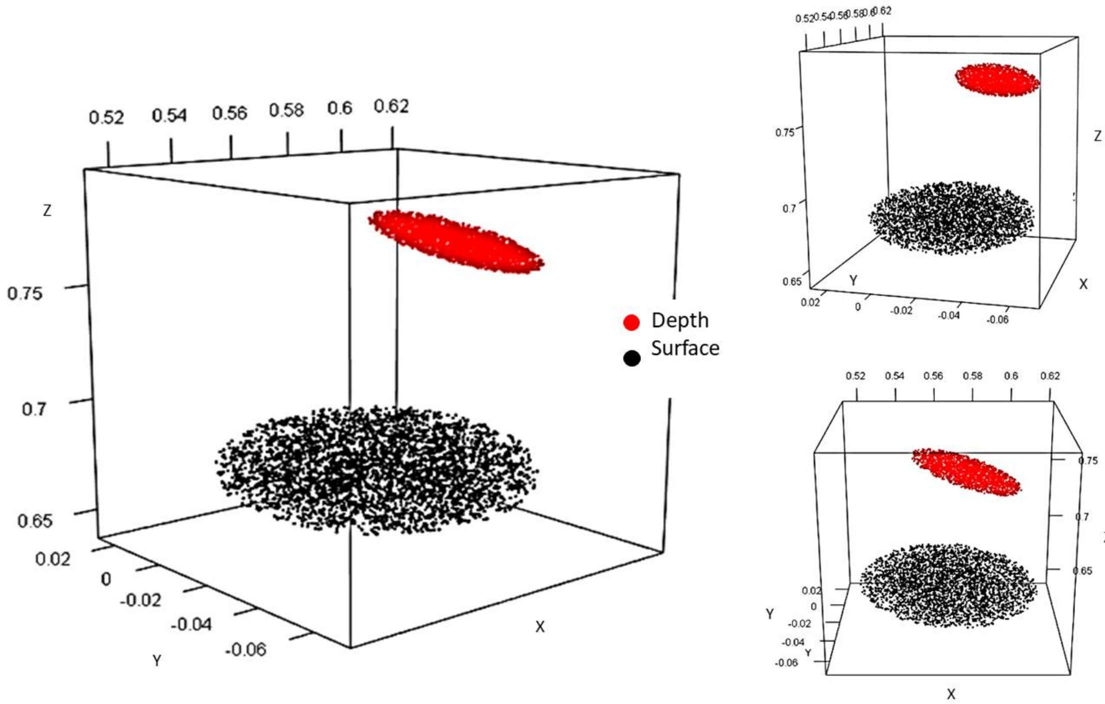


Fig. 12 Graphic representation of confidence ellipse of foliation data showing the different views and the three axes of the direction cosines, the red points concentration is the simulated data based on real depth data and the black points concentration is the simulation data based on real surface data

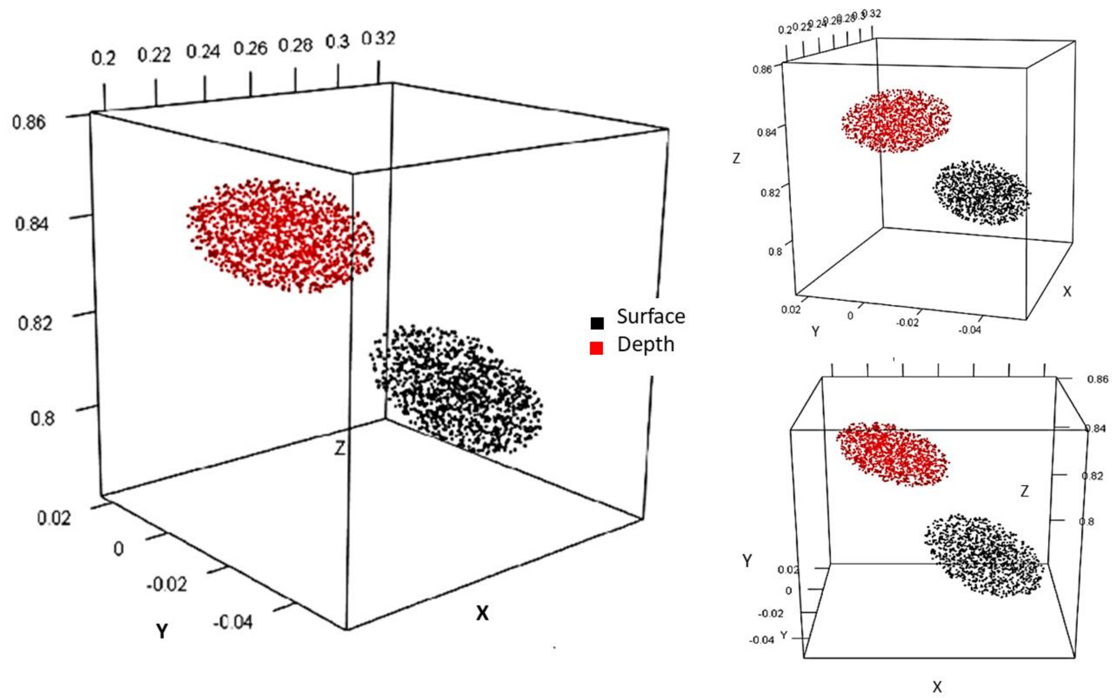


Fig. 13 Graphic representation of confidence ellipse of joints data showing the different views and the three axes of the direction cosines, the red points concentration is the simulated data based on real depth data and the black points concentration is the simulation data based on real surface data

These analyzes show that the simulation is following real measurements in the place the surface measurements are obtained. It is possible to simulate a model using the Monte Carlo methods and estimate the depth conditions. It is important to accentuate that simulation is possible for the one geological unit, all these analyzes were done for the schist of Araxá Group, rocks that compose the works area.

5. Discussion

Initially, the mean values were obtained for all structures set without distinction between foliation and joint. The result of this analysis gives us a general idea of the spatial arrangement of the structures present in the studied massif. Despite the described analyses to show a certain similarity between the surface and depth data, mainly concerning the direction, these structures should be discussed separately to highlight the differences between them. To understand this contrast and apply the Monte Carlo simulation, the foliation and joints were examined separately, distinguishing the position of the measures on the surface and in-depth.

The directions of joints are not evident when all the measurements are plotted together in the same diagram (Fig.5a and 5b), but we can distinguish only two main systems (*J1* and *J2*). When were separated foliation and joints, it is possible to identify *J1* and *J2* sets plus two sets with less concentration named *J3* and *J4* sets (Fig.5c and 5d) when the planar structures, obtained in surface and depth, are analyzed together.

At different depth intervals, the mean values of the foliation orientations were calculated, the former shows no significant variation in direction and plunge along with the depth (Fig.7b and 7d). When we analyze the joint orientation, we remark the appearance of the system (*J4*) with higher concentration occur in the interval of 41 to 60 m of depth (Fig.8d), which has not been identified easily on the surface and the 0 to 40 m of depth due to a less concentration (Fig.8b). Compared to other systems, *J4* set has a longitudinal direction to *J2//fol* with an opposite plunge, suggesting the presence of folds (Fig. 14).

The angle between *J1* and *J3* systems is ~ 60 degrees and could be related to a conjugate system. The spatial arrangement of the conjugate system enables the identification of the σ1 direction, that correspondent to the E-W direction, coherent with the N-S direction of the foliation planes (Fig.15).

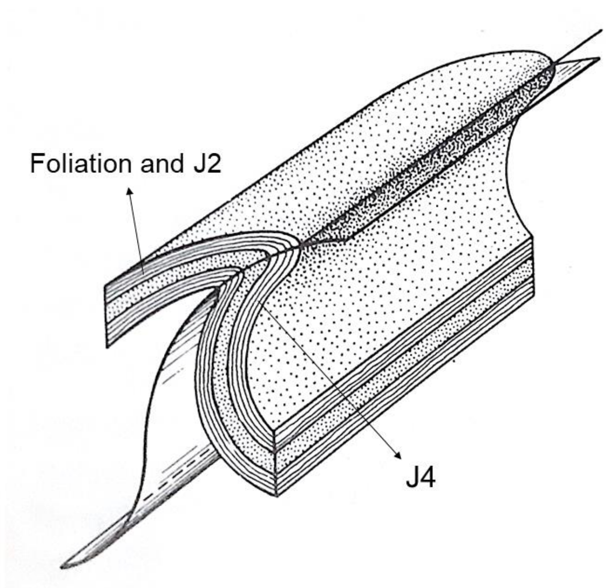


Figure 14 Fold model shows the position of foliation and J4

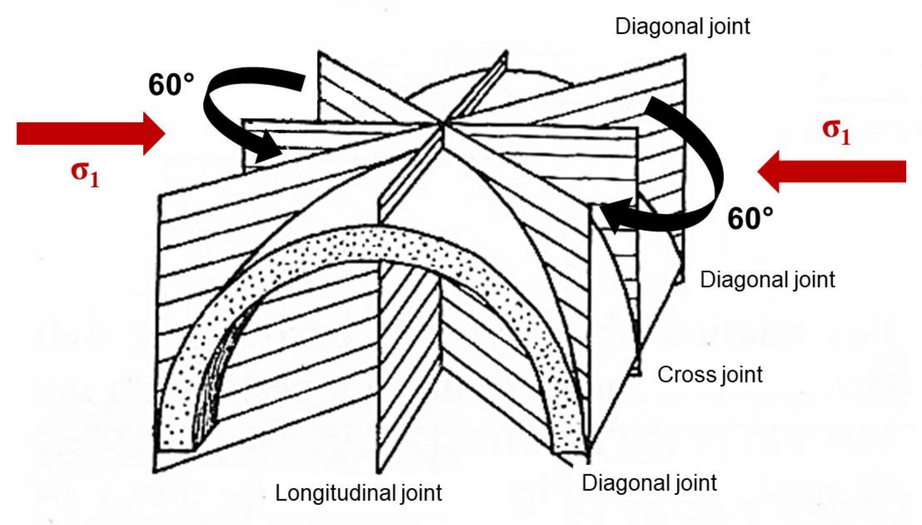


Figure 15. Arrangement of joints and the conjugate system model.

From the average of the values, new data were created from simulated direction cosines, allowing to compare surface and depth data, checking the correspondence between them, and calculating the percentage of this correspondence.

The question is: *Is it possible to know or evaluate the data of these structures in depth using Monte Carlo simulation?* It is important to emphasize that the simulation was carried out in only a single geological unit (Schist Araxá), as described above. Comparing the behavior of the foliation data with those created by simulation allowed us to know how close or different these data are. For example, in the foliation simulation data (Fig. 12) the similarity is around 96%, and for joint data, the difference is also low, showing similarity of round 95% (Fig. 13). These results are suggesting, favorably to use the simulation for optimization of prediction of geological conditions.

The low difference between the spatial orientations of the structures in surface and depth attest that the simulation results presented highlight the feasibility of using the Monte Carlo simulation, to understand the geological structures behavior from the surface to the depth.

6. Conclusion

Descriptive analysis shows the importance of understanding the configuration of the geological structures of rock massif, and employing description of data it is possible to identify some differences and/or similarities that allowed to make a correlation between surface and depth data through Monte Carlo simulation.

The foliation measures of different depth intervals are quite similar to surface measures, indicating that the direction and plunge of foliation remain remarkably similar from the surface to a depth of 60 meters, only a 4% difference can be determined through simulation. The joints measures also show a small difference among the distinct levels, however, the short difference between joints surface and depth data, as shown by the simulation, probably can be attributed to the appearance of fractures due to detonations for tunnel opening.

The simulation data using Monte Carlo show that is possible to obtain information and create correlations between surface and depth data and estimate the percentage of correspondence between them. The use of Monte Carlo simulation proves to be a powerful and promising tool in geological investigations for large engineering enterprises (projects). In a future project, we intend to apply this simulation in different units and observe its behavior.

Author contribution

Bruna Catarino Xavier was responsible to write the paper, and compilation of data, and constructing statistical analyzes.

Marcos Egydio-Silva contributed to writing the paper, especially in geology structural.

Georg Robert Sadowski contributed to write the paper and compilation of data.

Bruno de Assis da Silva contributed to constructing statistical analyzes.

Victor Junji Takara contributed to constructing statistical analyzes.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary Material

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
0 - 10	53	280	0,645771823	1,745329252	0,592672101	-0,104504082	0,79863551	foliation
10	56	274	0,593411946	1,640609497	0,557830738	-0,039007325	0,829037573	foliation
10	25	264	1,134464014	1,466076572	0,901342938	0,09473496	0,422618262	joint
10	83	22	0,122173048	-2,757620218	-0,04565306	-0,112995288	0,992546152	joint
10	68	270	0,383972435	1,570796327	0,374606593	2,29474E-17	0,927183855	foliation
10	55	278	0,610865238	1,710422667	0,56799443	-0,079826411	0,819152044	foliation
10	60	255	0,523598776	1,308996939	0,482962913	0,129409523	0,866025404	foliation
10	44	299	0,802851456	2,07694181	0,629148766	-0,348742855	0,69465837	joint
10	33	291	0,994837674	1,93731547	0,782966427	-0,300552652	0,544639035	joint
10	62	258	0,488692191	1,361356817	0,459212483	0,097608626	0,882947593	foliation
10	89	218	0,017453293	0,663225116	0,010744774	0,013752684	0,999847695	joint
10	80	350	0,174532925	2,967059728	0,03015369	-0,171010072	0,984807753	joint
10	76	322	0,244346095	2,478367538	0,148941991	-0,190637055	0,970295726	joint
10	89	108	0,017453293	-1,256637061	-0,016598225	0,00539309	0,999847695	joint
10	62	200	0,488692191	0,34906585	0,160568731	0,441158963	0,882947593	joint
10	47	279	0,750491578	1,727875959	0,673601829	-0,106688049	0,731353702	joint
10	83	202	0,122173048	0,383972435	0,04565306	0,112995288	0,992546152	joint
10	62	330	0,488692191	2,617993878	0,234735781	-0,4065743	0,882947593	joint
10	33	291	0,994837674	1,93731547	0,782966427	-0,300552652	0,544639035	joint
10	45	268	0,785398163	1,535889742	0,706676031	0,024677671	0,707106781	joint
10	71	218	0,331612558	0,663225116	0,20043977	0,256551207	0,945518576	joint
10	52	268	0,663225116	1,535889742	0,615286431	0,021486276	0,788010754	joint
10	56	73	0,593411946	-1,8675023	-0,534758833	-0,163492182	0,829037573	joint
10	84	32	0,104719755	-2,583087293	-0,055391646	-0,088645164	0,994521895	joint
10	89	198	0,017453293	0,314159265	0,00539309	0,016598225	0,999847695	joint
10	74	236	0,27925268	0,977384381	0,228513724	0,154134453	0,961261696	joint
10	22	124	1,186823891	-0,977384381	-0,768670252	0,518474632	0,374606593	joint
10	51	358	0,680678408	3,106686069	0,021962965	-0,628937026	0,777145961	joint
10	38	165	0,907571211	-0,261799388	-0,203952191	0,761159938	0,615661475	joint
10	53	282	0,645771823	1,780235837	0,588663921	-0,125124379	0,79863551	joint
10	73	208	0,296705973	0,488692191	0,137260201	0,258148893	0,956304756	joint
10	41	267	0,855211333	1,518436449	0,753675277	0,039498448	0,656059029	joint
10	48	291	0,733038286	1,93731547	0,624687237	-0,239794963	0,743144825	joint
10	23	152	1,169370599	-0,488692191	-0,432150852	0,812757545	0,390731128	joint
11 - 20	70	275	0,34906585	1,658062789	0,340718653	-0,02980902	0,939692621	foliation
20	62	206	0,488692191	0,453785606	0,205802787	0,421958246	0,882947593	foliation
20	46	318	0,767944871	2,408554368	0,464817177	-0,516231773	0,7193398	joint
20	68	275	0,383972435	1,658062789	0,373181102	-0,032649116	0,927183855	foliation
20	65	274	0,436332313	1,640609497	0,421588785	-0,02948036	0,906307787	foliation
20	72	269	0,314159265	1,553343034	0,30896993	0,00539309	0,951056516	foliation
20	50	274	0,698131701	1,640609497	0,641221811	-0,044838597	0,766044443	foliation
20	58	275	0,558505361	1,658062789	0,527902761	-0,046185507	0,848048096	foliation
20	86	341	0,06981317	2,809980096	0,022710486	-0,065956042	0,99756405	joint
20	73	274	0,296705973	1,640609497	0,291659502	-0,020394819	0,956304756	joint
20	58	254	0,558505361	1,291543646	0,509391091	0,146065545	0,848048096	foliation
20	85	258	0,087266463	1,361356817	0,085251181	0,018120698	0,996194698	foliation
20	89	275	0,017453293	1,658062789	0,017385995	-0,001521077	0,999847695	foliation
20	88	276	0,034906585	1,675516082	0,034708314	-0,003647991	0,999390827	foliation
20	60	278	0,523598776	1,710422667	0,495134034	-0,06958655	0,866025404	foliation
20	58	282	0,558505361	1,780235837	0,518339257	-0,11017641	0,848048096	foliation
20	52	297	0,663225116	2,042035225	0,548558391	-0,279504461	0,788010754	foliation
20	81	346	0,157079633	2,897246558	0,037844922	-0,151787693	0,987688341	joint
20	80	154	0,174532925	-0,453785606	-0,076122351	0,156073948	0,984807753	joint
20	60	13	0,523598776	-2,914699851	-0,112475527	-0,487185032	0,866025404	joint
20	78	337	0,20943951	2,740166926	0,08123757	-0,19138372	0,978147601	joint
20	89	110	0,017453293	-1,221730476	-0,016399898	0,005969075	0,999847695	joint

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
20	57	80	0,575958653	-1,745329252	-0,536364744	-0,094575576	0,838670568	joint
20	65	263	0,436332313	1,448623279	0,419468129	0,05150421	0,906307787	foliation
20	43	282	0,820304748	1,780235837	0,715371869	-0,152056985	0,68199836	foliation
20	70	305	0,34906585	2,181661565	0,2801665	-0,196174695	0,939692621	foliation
20	70	305	0,34906585	2,181661565	0,2801665	-0,196174695	0,939692621	foliation
21 - 30	50	268	0,698131701	1,535889742	0,642396041	0,022432964	0,766044443	foliation
30	53	269	0,645771823	1,553343034	0,601723364	0,01050312	0,79863551	foliation
30	59	275	0,541052068	1,658062789	0,5130782	-0,044888526	0,857167301	foliation
30	62	240	0,488692191	1,047197551	0,4065743	0,234735781	0,882947593	foliation
30	65	253	0,436332313	1,274090354	0,404151854	0,123561622	0,906307787	foliation
30	64	280	0,453785606	1,745329252	0,431711304	-0,076122351	0,898794046	foliation
30	89	33	0,017453293	-2,565634	-0,009505262	-0,01463682	0,999847695	joint
30	30	255	1,047197551	1,308996939	0,836516304	0,224143868	0,5	foliation
30	68	250	0,383972435	1,221730476	0,352015052	0,128123001	0,927183855	foliation
30	80	202	0,174532925	0,383972435	0,065049752	0,161003787	0,984807753	joint
30	85	11	0,087266463	-2,949606436	-0,0166301	-0,085554446	0,996194698	joint
30	42	173	0,837758041	-0,122173048	-0,090566572	0,737605537	0,669130606	joint
30	60	80	0,523598776	-1,745329252	-0,492403877	-0,086824089	0,866025404	joint
30	15	41	1,308996939	-2,42600766	-0,63370436	-0,728993475	0,258819045	joint
30	70	208	0,34906585	0,488692191	0,160568731	0,301985862	0,939692621	joint
30	89	235	0,017453293	0,959931089	0,014296174	0,010010289	0,999847695	joint
30	50	289	0,698131701	1,902408885	0,607767625	-0,209271176	0,766044443	joint
30	86	223	0,06981317	0,750491578	0,047573801	0,051016655	0,99756405	joint
30	89	235	0,017453293	0,959931089	0,014296174	0,010010289	0,999847695	joint
30	78	48	0,20943951	-2,303834613	-0,154508497	-0,139120076	0,978147601	joint
30	30	255	1,047197551	1,308996939	0,836516304	0,224143868	0,5	foliation
30	86	223	0,06981317	0,750491578	0,047573801	0,051016655	0,99756405	foliation
30	80	202	0,174532925	0,383972435	0,065049752	0,161003787	0,984807753	joint
30	85	11	0,087266463	-2,949606436	-0,0166301	-0,085554446	0,996194698	joint
30	15	141	1,308996939	-0,680678408	-0,607876819	0,750665355	0,258819045	joint
30	70	208	0,34906585	0,488692191	0,160568731	0,301985862	0,939692621	joint
30	89	235	0,017453293	0,959931089	0,014296174	0,010010289	0,999847695	joint
30	50	289	0,698131701	1,902408885	0,607767625	-0,209271176	0,766044443	joint
30	53	200	0,645771823	0,34906585	0,20583286	0,565521136	0,79863551	joint
30	60	80	0,523598776	-1,745329252	-0,492403877	-0,086824089	0,866025404	joint
30	50	280	0,698131701	1,745329252	0,633022222	-0,111618897	0,766044443	foliation
30	54	280	0,628318531	1,745329252	0,578855474	-0,102067838	0,809016994	foliation
30	42	285	0,837758041	1,832595715	0,71782278	-0,192340034	0,669130606	foliation
30	57	286	0,575958653	1,850049007	0,523540642	-0,150122863	0,838670568	foliation
30	50	290	0,698131701	1,919862177	0,604022774	-0,21984631	0,766044443	foliation
30	63	295	0,471238898	2,00712864	0,411455125	-0,191864676	0,891006524	foliation
30	88	15	0,034906585	-2,879793266	-0,009032654	-0,033710325	0,999390827	joint
30	53	70	0,645771823	-1,919862177	-0,565521136	-0,20583286	0,79863551	joint
30	55	88	0,610865238	-1,605702912	-0,573227029	-0,020017529	0,819152044	joint
30	82	150	0,13962634	-0,523598776	-0,06958655	0,120527441	0,990268069	joint
30	81	195	0,157079633	0,261799388	0,040488219	0,15110409	0,987688341	joint
30	50	272	0,698131701	1,605702912	0,642396041	-0,022432964	0,766044443	joint
30	83	360	0,122173048	3,141592654	1,49308E-17	-0,121869343	0,992546152	joint
30	78	208	0,20943951	0,488692191	0,097608626	0,183575127	0,978147601	joint
30	63	95	0,471238898	-1,483529864	-0,452262929	0,039567879	0,891006524	joint
30	57	287	0,575958653	1,8675023	0,520840899	-0,159237043	0,838670568	foliation
30	59	295	0,541052068	2,00712864	0,466783018	-0,217664496	0,857167301	foliation
30	52	297	0,663225116	2,042035225	0,548558391	-0,279504461	0,788010754	foliation
30	87	23	0,052359878	-2,740166926	-0,020449287	-0,048175502	0,998629535	joint
30	50	293	0,698131701	1,972222055	0,591689114	-0,251157128	0,766044443	foliation
30	30	255	1,047197551	1,308996939	0,836516304	0,224143868	0,5	foliation
30	53	283	0,645771823	1,79768913	0,586390543	-0,135378924	0,79863551	foliation

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
30	40	273	0,872664626	1,623156204	0,764994606	-0,040091668	0,64278761	foliation
30	87	352	0,052359878	3,001966313	0,007283757	-0,051826626	0,998629535	joint
30	80	40	0,174532925	-2,443460953	-0,111618897	-0,133022222	0,984807753	joint
30	70	45	0,34906585	-2,35619449	-0,241844763	-0,241844763	0,939692621	joint
30	78	48	0,20943951	-2,303834613	-0,154508497	-0,139120076	0,978147601	joint
30	88	223	0,034906585	0,750491578	0,0238014	0,025523876	0,999390827	joint
30	63	162	0,471238898	-0,314159265	-0,14029078	0,431770623	0,891006524	joint
30	50	293	0,698131701	1,972222055	0,591689114	-0,251157128	0,766044443	foliation
30	68	250	0,383972435	1,221730476	0,352015052	0,128123001	0,927183855	foliation
30	40	273	0,872664626	1,623156204	0,764994606	-0,040091668	0,64278761	foliation
30	53	283	0,645771823	1,79768913	0,586390543	-0,135378924	0,79863551	foliation
30	87	352	0,052359878	3,001966313	0,007283757	-0,051826626	0,998629535	joint
30	80	40	0,174532925	-2,443460953	-0,111618897	-0,133022222	0,984807753	joint
30	70	45	0,34906585	-2,35619449	-0,241844763	-0,241844763	0,939692621	joint
30	88	223	0,034906585	0,750491578	0,0238014	0,025523876	0,999390827	joint
30	78	48	0,20943951	-2,303834613	-0,154508497	-0,139120076	0,978147601	joint
30	45	81	0,785398163	-1,727875959	-0,698401123	-0,110615871	0,707106781	joint
30	63	162	0,471238898	-0,314159265	-0,14029078	0,431770623	0,891006524	joint
30	50	268	0,698131701	1,535889742	0,642396041	0,022432964	0,766044443	foliation
30	45	280	0,785398163	1,745329252	0,69636424	-0,122787804	0,707106781	foliation
30	42	288	0,837758041	1,884955592	0,706772729	-0,22964438	0,669130606	foliation
30	31	299	1,029744259	2,07694181	0,749695414	-0,415562954	0,515038075	foliation
30	78	18	0,20943951	-2,827433388	-0,064248246	-0,197735768	0,978147601	joint
30	60	22	0,523598776	-2,757620218	-0,187303297	-0,463591927	0,866025404	joint
30	58	73	0,558505361	-1,8675023	-0,506764313	-0,154933399	0,848048096	joint
30	60	90	0,523598776	-1,570796327	-0,5	3,06287E-17	0,866025404	joint
30	81	188	0,157079633	0,13962634	0,02177147	0,154912056	0,987688341	joint
30	54	200	0,628318531	0,34906585	0,201034396	0,552337464	0,809016994	joint
30	81	223	0,157079633	0,750491578	0,106688049	0,114408925	0,987688341	joint
30	89	343	0,017453293	2,844886681	0,00510259	-0,016689819	0,999847695	joint
30	86	141	0,06981317	-0,680678408	-0,043899171	0,054210962	0,99756405	joint
30	85	348	0,087266463	2,932153143	0,018120698	-0,085251181	0,996194698	joint
30	89	350	0,017453293	2,967059728	0,003030579	-0,017187265	0,999847695	joint
30	40	278	0,872664626	1,710422667	0,758589351	-0,106612781	0,64278761	foliation
30	88	33	0,034906585	-2,565634	-0,019007628	-0,029269181	0,999390827	joint
30	77	348	0,226892803	2,932153143	0,046769954	-0,220035334	0,974370065	joint
30	73	227	0,296705973	0,820304748	0,213827128	0,199397023	0,956304756	joint
30	89	225	0,017453293	0,785398163	0,012340715	0,012340715	0,999847695	joint
30	45	284	0,785398163	1,815142422	0,686102688	-0,171064613	0,707106781	joint
30	62	189	0,488692191	0,157079633	0,073441533	0,463691589	0,882947593	joint
30	88	33	0,034906585	-2,565634	-0,019007628	-0,029269181	0,999390827	joint
30	89	225	0,017453293	0,785398163	0,012340715	0,012340715	0,999847695	joint
30	40	278	0,872664626	1,710422667	0,758589351	-0,106612781	0,64278761	joint
30	77	348	0,226892803	2,932153143	0,046769954	-0,220035334	0,974370065	joint
30	45	284	0,785398163	1,815142422	0,686102688	-0,171064613	0,707106781	joint
30	73	227	0,296705973	0,820304748	0,213827128	0,199397023	0,956304756	joint
30	62	189	0,488692191	0,157079633	0,073441533	0,463691589	0,882947593	joint
30	42	288	0,837758041	1,884955592	0,706772729	-0,22964438	0,669130606	foliation
30	53	287	0,645771823	1,8675023	0,575518569	-0,175953684	0,79863551	foliation
30	52	315	0,663225116	2,35619449	0,435338404	-0,435338404	0,788010754	foliation
30	80	18	0,174532925	-2,827433388	-0,053660238	-0,165149231	0,984807753	joint
30	54	27	0,628318531	-2,670353756	-0,26684892	-0,523720495	0,809016994	joint
30	74	33	0,27925268	-2,565634	-0,150122863	-0,231168938	0,961261696	joint
30	84	70	0,104719755	-1,919862177	-0,098224626	-0,03575084	0,994521895	joint
30	88	87	0,034906585	-1,623156204	-0,034851668	-0,001826499	0,999390827	joint
30	89	90	0,017453293	-1,570796327	-0,017452406	1,06909E-18	0,999847695	joint
30	70	113	0,34906585	-1,169370599	-0,314831202	0,133637917	0,939692621	joint

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
30	82	198	0,13962634	0,314159265	0,043006853	0,132361485	0,990268069	joint
30	79	208	0,191986218	0,488692191	0,089579397	0,168474343	0,981627183	joint
30	84	209	0,104719755	0,506145483	0,050676405	0,091422654	0,994521895	joint
30	80	270	0,174532925	1,570796327	0,173648178	1,06372E-17	0,984807753	joint
30	67	347	0,401425728	2,914699851	0,087895379	-0,380716715	0,920504853	joint
30	61	292	0,506145483	1,954768762	0,449507652	-0,18161288	0,874619707	joint
31 - 40	38	292	0,907571211	1,954768762	0,730630848	-0,295194024	0,615661475	foliation
40	50	272	0,698131701	1,605702912	0,642396041	-0,022432964	0,766044443	foliation
40	89	225	0,017453293	0,785398163	0,012340715	0,012340715	0,999847695	joint
40	88	32	0,034906585	-2,583087293	-0,018493916	-0,029596452	0,999390827	joint
40	88	354	0,034906585	3,036872898	0,003647991	-0,034708314	0,999390827	joint
40	38	292	0,907571211	1,954768762	0,730630848	-0,295194024	0,615661475	foliation
40	50	272	0,698131701	1,605702912	0,642396041	-0,022432964	0,766044443	foliation
40	40	282	0,872664626	1,780235837	0,749304534	-0,159269595	0,64278761	foliation
40	88	354	0,034906585	3,036872898	0,003647991	-0,034708314	0,999390827	joint
40	88	32	0,034906585	-2,583087293	-0,018493916	-0,029596452	0,999390827	joint
40	42	254	0,837758041	1,291543646	0,714356655	0,204838475	0,669130606	foliation
40	62	274	0,488692191	1,640609497	0,468327954	-0,032748681	0,882947593	foliation
40	40	276	0,872664626	1,675516082	0,761847972	-0,080073448	0,64278761	foliation
40	54	27	0,628318531	-2,670353756	-0,26684892	-0,523720495	0,809016994	joint
40	89	90	0,017453293	-1,570796327	-0,017452406	1,06909E-18	0,999847695	joint
40	84	70	0,104719755	-1,919862177	-0,098224626	-0,03575084	0,994521895	joint
40	68	109	0,383972435	-1,239183769	-0,354197493	0,121959977	0,927183855	joint
40	70	260	0,34906585	1,396263402	0,336824089	0,059391175	0,939692621	joint
40	75	320	0,261799388	2,443460953	0,166365675	-0,198266891	0,965925826	joint
40	89	328	0,017453293	2,583087293	0,009248366	-0,01480048	0,999847695	joint
40	68	342	0,383972435	2,827433388	0,115759804	-0,356272042	0,927183855	joint
40	64	67	0,453785606	-1,972222055	-0,403522768	-0,171285253	0,898794046	joint
40	53	281	0,645771823	1,762782545	0,590757986	-0,11483172	0,79863551	joint
40	57	266	0,575958653	1,500983157	0,543312322	0,037992099	0,838670568	joint
40	87	229	0,052359878	0,855211333	0,039498448	0,034335477	0,998629535	joint
40	89	167	0,017453293	-0,226892803	-0,003925937	0,017005102	0,999847695	joint
40	19	162	1,239183769	-0,314159265	-0,292181308	0,899241603	0,325568154	joint
40	42	260	0,837758041	1,396263402	0,731854786	0,129045745	0,669130606	foliation
40	54	255	0,628318531	1,308996939	0,567756956	0,152130018	0,809016994	joint
40	60	248	0,523598776	1,186823891	0,463591927	0,187303297	0,866025404	joint
40	80	33	0,174532925	-2,565634	-0,094575576	-0,145633616	0,984807753	joint
40	70	43	0,34906585	-2,391101075	-0,233257177	-0,250137698	0,939692621	joint
40	42	260	0,837758041	1,396263402	0,731854786	0,129045745	0,669130606	foliation
40	60	248	0,523598776	1,186823891	0,463591927	0,187303297	0,866025404	joint
40	54	255	0,628318531	1,308996939	0,567756956	0,152130018	0,809016994	joint
40	70	43	0,34906585	-2,391101075	-0,233257177	-0,250137698	0,939692621	joint
40	45	276	0,785398163	1,675516082	0,703233176	-0,073912785	0,707106781	foliation
40	62	274	0,488692191	1,640609497	0,468327954	-0,032748681	0,882947593	foliation
40	75	40	0,261799388	-2,443460953	-0,166365675	-0,198266891	0,965925826	joint
40	44	271	0,802851456	1,588249619	0,719230241	-0,012554211	0,69465837	joint
40	50	305	0,698131701	2,181661565	0,526540785	-0,368687826	0,766044443	joint
40	36	72	0,942477796	-1,884955592	-0,769420884	-0,25	0,587785252	joint
40	68	142	0,383972435	-0,663225116	-0,230630848	0,295194024	0,927183855	joint
40	58	288	0,558505361	1,884955592	0,503983169	-0,163754058	0,848048096	joint
40	63	287	0,471238898	1,8675023	0,434153274	-0,132733976	0,891006524	joint
40	28	239	1,082104136	1,029744259	0,756833805	0,454751628	0,469471563	joint
40	54	303	0,628318531	2,14675498	0,492958191	-0,320130793	0,809016994	joint
40	86	43	0,06981317	-2,391101075	-0,047573801	-0,051016655	0,99756405	joint
40	60	277	0,523598776	1,692969374	0,496273076	-0,060934672	0,866025404	joint
40	62	279	0,488692191	1,727875959	0,463691589	-0,073441533	0,882947593	joint
40	61	283	0,506145483	1,79768913	0,472383981	-0,109058435	0,874619707	joint

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
40	51	278	0,680678408	1,710422667	0,623195888	-0,08758447	0,777145961	joint
40	24	170	1,151917306	-0,174532925	-0,158635504	0,899666649	0,406736643	joint
40	62	284	0,488692191	1,815142422	0,455526251	-0,11357545	0,882947593	joint
40	48	279	0,733038286	1,727875959	0,660892498	-0,104675088	0,743144825	joint
40	41	284	0,855211333	1,815142422	0,73229148	-0,182580772	0,656059029	joint
40	27	266	1,099557429	1,500983157	0,888836077	0,062153473	0,4539905	joint
40	56	281	0,593411946	1,762782545	0,548918955	-0,106699036	0,829037573	joint
40	79	28	0,191986218	-2,652900463	-0,089579397	-0,168474343	0,981627183	joint
40	63	283	0,471238898	1,79768913	0,442354753	-0,102125642	0,891006524	joint
40	72	248	0,314159265	1,186823891	0,286515568	0,115759804	0,951056516	joint
40	53	220	0,645771823	0,698131701	0,38683924	0,461017054	0,79863551	joint
40	80	33	0,174532925	-2,565634	-0,094575576	-0,145633616	0,984807753	joint
40	50	289	0,698131701	1,902408885	0,607767625	-0,209271176	0,766044443	joint
40	52	278	0,663225116	1,710422667	0,6096699	-0,085683517	0,788010754	joint
40	56	262	0,593411946	1,431169987	0,553750877	0,07782461	0,829037573	joint
40	59	258	0,541052068	1,361356817	0,503783257	0,107082437	0,857167301	joint
40	50	271	0,698131701	1,588249619	0,64268971	-0,011218191	0,766044443	foliation
40	52	281	0,663225116	1,762782545	0,60435004	-0,117473748	0,788010754	foliation
40	89	204	0,017453293	0,41887902	0,007098533	0,015943567	0,999847695	joint
40	50	271	0,698131701	1,588249619	0,64268971	-0,011218191	0,766044443	foliation
40	52	281	0,663225116	1,762782545	0,60435004	-0,117473748	0,788010754	foliation
40	80	33	0,174532925	-2,565634	-0,094575576	-0,145633616	0,984807753	joint
40	89	204	0,017453293	0,41887902	0,007098533	0,015943567	0,999847695	joint
40	44	271	0,802851456	1,588249619	0,719230241	-0,012554211	0,69465837	foliation
40	57	295	0,575958653	2,00712864	0,493610599	-0,230174402	0,838670568	foliation
40	78	60	0,20943951	-2,094395102	-0,180056806	-0,103955845	0,978147601	joint
40	40	291	0,872664626	1,93731547	0,715164098	-0,274525776	0,64278761	joint
40	88	340	0,034906585	2,792526803	0,011936331	-0,0327948	0,999390827	joint
40	49	331	0,715584993	2,635447171	0,318063729	-0,573802156	0,75470958	joint
40	27	236	1,099557429	0,977384381	0,738677886	0,498244525	0,4539905	joint
40	81	120	0,157079633	-1,047197551	-0,135476221	0,078217233	0,987688341	joint
40	72	238	0,314159265	1,012290966	0,262061274	0,163754058	0,951056516	joint
40	30	174	1,047197551	-0,104719755	-0,090524305	0,861281226	0,5	joint
40	60	225	0,523598776	0,785398163	0,353553391	0,353553391	0,866025404	joint
40	61	250	0,506145483	1,221730476	0,455572023	0,165814656	0,874619707	joint
40	60	284	0,523598776	1,815142422	0,485147863	-0,120960948	0,866025404	joint
40	32	241	1,012290966	1,064650844	0,741719578	0,411141875	0,529919264	joint
40	71	234	0,331612558	0,942477796	0,26339017	0,19136416	0,945518576	joint
40	71	239	0,331612558	1,029744259	0,279066376	0,167679996	0,945518576	joint
40	72	236	0,314159265	0,977384381	0,256186699	0,17280011	0,951056516	joint
40	24	300	1,151917306	2,094395102	0,791153574	-0,456772729	0,406736643	joint
40	80	288	0,174532925	1,884955592	0,165149231	-0,053660238	0,984807753	joint
40	28	255	1,082104136	1,308996939	0,852861883	0,228523653	0,469471563	joint
40	49	283	0,715584993	1,79768913	0,639244279	-0,14758117	0,75470958	joint
40	70	226	0,34906585	0,802851456	0,246028702	0,237587155	0,939692621	joint
40	49	281	0,715584993	1,762782545	0,644005377	-0,125181964	0,75470958	joint
40	67	177	0,401425728	-0,052359878	-0,020449287	0,390195645	0,920504853	joint
40	57	277	0,575958653	1,692969374	0,540579378	-0,066374802	0,838670568	joint
40	52	218	0,663225116	0,663225116	0,379039052	0,485147863	0,788010754	joint
40	60	286	0,523598776	1,850049007	0,480630848	-0,137818678	0,866025404	joint
40	52	273	0,663225116	1,623156204	0,614817733	-0,032221232	0,788010754	joint
40	48	289	0,733038286	1,902408885	0,632675418	-0,217847617	0,743144825	joint
40	63	3	0,471238898	-3,089232776	-0,023760027	-0,453368322	0,891006524	joint
40	25	298	1,134464014	2,059488517	0,800222279	-0,425485733	0,422618262	joint
40	88	215	0,034906585	0,610865238	0,020017529	0,028587994	0,999390827	joint
40	88	188	0,034906585	0,13962634	0,004857071	0,034559857	0,999390827	joint
40	40	273	0,872664626	1,623156204	0,764994606	-0,040091668	0,64278761	foliation

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
40	35	265	0,959931089	1,483529864	0,816034923	0,071393805	0,573576436	foliation
40	41	272	0,855211333	1,605702912	0,754249832	-0,026338985	0,656059029	foliation
40	79	343	0,191986218	2,844886681	0,055787151	-0,18247155	0,981627183	joint
40	87	201	0,052359878	0,366519143	0,018755529	0,048859824	0,998629535	joint
40	40	273	0,872664626	1,623156204	0,764994606	-0,040091668	0,64278761	foliation
40	41	272	0,855211333	1,605702912	0,754249832	-0,026338985	0,656059029	foliation
40	79	343	0,191986218	2,844886681	0,055787151	-0,18247155	0,981627183	joint
40	35	265	0,959931089	1,483529864	0,816034923	0,071393805	0,573576436	joint
40	87	201	0,052359878	0,366519143	0,018755529	0,048859824	0,998629535	joint
40	50	283	0,698131701	1,79768913	0,626313005	-0,144595751	0,766044443	foliation
40	83	38	0,122173048	-2,478367538	-0,07503026	-0,096034353	0,992546152	joint
40	77	46	0,226892803	-2,338741198	-0,161816247	-0,156264133	0,974370065	joint
40	80	35	0,174532925	-2,530727415	-0,099600503	-0,14224426	0,984807753	joint
40	87	214	0,052359878	0,593411946	0,029265895	0,043388474	0,998629535	joint
40	87	45	0,052359878	-2,35619449	-0,03700711	-0,03700711	0,998629535	joint
40	68	40	0,383972435	-2,443460953	-0,240792477	-0,286965299	0,927183855	joint
40	70	45	0,34906585	-2,35619449	-0,241844763	-0,241844763	0,939692621	joint
40	87	238	0,052359878	1,012290966	0,044383408	0,027733831	0,998629535	joint
40	49	69	0,715584993	-1,93731547	-0,612483868	-0,235110529	0,75470958	joint
40	46	315	0,767944871	2,35619449	0,491197644	-0,491197644	0,7193398	joint
40	48	287	0,733038286	1,8675023	0,639892781	-0,195634856	0,743144825	joint
40	52	293	0,663225116	1,972222055	0,566719376	-0,240558103	0,788010754	joint
40	87	220	0,052359878	0,698131701	0,033640904	0,040091668	0,998629535	joint
40	85	218	0,087266463	0,663225116	0,053658433	0,068679663	0,996194698	joint
40	64	241	0,453785606	1,064650844	0,383408044	0,212526549	0,898794046	joint
40	62	287	0,488692191	1,8675023	0,448957888	-0,137260201	0,882947593	joint
40	53	296	0,645771823	2,024581932	0,54090776	-0,263818342	0,79863551	joint
40	56	282	0,593411946	1,780235837	0,546973197	-0,116262742	0,829037573	joint
40	86	31	0,06981317	-2,600540585	-0,03592724	-0,059792968	0,99756405	joint
40	49	219	0,715584993	0,680678408	0,412871325	0,509853625	0,75470958	joint
40	69	188	0,366519143	0,13962634	0,049875179	0,354880337	0,933580426	joint
40	86	35	0,06981317	-2,530727415	-0,04001067	-0,057141158	0,99756405	joint
40	48	271	0,733038286	1,588249619	0,669028695	-0,011677939	0,743144825	joint
40	74	47	0,27925268	-2,321287905	-0,2015884	-0,187984225	0,961261696	joint
40	78	233	0,20943951	0,925024504	0,166045659	0,125124379	0,978147601	joint
40	40	264	0,872664626	1,466076572	0,761847972	0,080073448	0,64278761	joint
40	84	348	0,104719755	2,932153143	0,02173269	-0,102244266	0,994521895	joint
40	55	281	0,610865238	1,762782545	0,563038222	-0,109443544	0,819152044	joint
40	87	199	0,052359878	0,331612558	0,017038921	0,049484619	0,998629535	joint
40	52	278	0,663225116	1,710422667	0,6096699	-0,085683517	0,788010754	joint
40	86	215	0,06981317	0,610865238	0,04001067	0,057141158	0,99756405	joint
40	53	278	0,645771823	1,710422667	0,595958201	-0,083756463	0,79863551	joint
40	78	288	0,20943951	1,884955592	0,197735768	-0,064248246	0,978147601	foliation
40	65	352	0,436332313	3,001966313	0,058817094	-0,41850537	0,906307787	joint
40	65	45	0,436332313	-2,35619449	-0,298836239	-0,298836239	0,906307787	joint
40	78	288	0,20943951	1,884955592	0,197735768	-0,064248246	0,978147601	foliation
40	65	45	0,436332313	-2,35619449	-0,298836239	-0,298836239	0,906307787	joint
40	58	29	0,558505361	-2,635447171	-0,256909957	-0,463477832	0,848048096	joint
40	79	208	0,191986218	0,488692191	0,089579397	0,168474343	0,981627183	joint
40	68	232	0,383972435	0,907571211	0,295194024	0,230630848	0,927183855	joint
40	54	269	0,628318531	1,553343034	0,58769573	0,010258267	0,809016994	foliation
40	55	275	0,610865238	1,658062789	0,571393805	-0,04999048	0,819152044	foliation
40	58	280	0,558505361	1,745329252	0,5218686	-0,092019515	0,848048096	foliation
40	19	251	1,239183769	1,239183769	0,894005377	0,307830738	0,325568154	joint
40	88	49	0,034906585	-2,28638132	-0,026338985	-0,02289613	0,999390827	joint
40	85	276	0,087266463	1,675516082	0,086678294	-0,009110256	0,996194698	joint
40	58	286	0,558505361	1,850049007	0,509391091	-0,146065545	0,848048096	joint

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
40	59	277	0,541052068	1,692969374	0,511199059	-0,062767352	0,857167301	joint
40	55	296	0,610865238	2,024581932	0,515527086	-0,25143936	0,819152044	joint
40	50	266	0,698131701	1,500983157	0,641221811	0,044838597	0,766044443	joint
40	52	289	0,663225116	1,902408885	0,582119361	-0,20043977	0,788010754	joint
40	26	270	1,117010721	1,570796327	0,898794046	5,50578E-17	0,438371147	joint
40	65	342	0,436332313	2,827433388	0,130596225	-0,401933852	0,906307787	joint
40	28	238	1,082104136	1,012290966	0,748782025	0,467890939	0,469471563	joint
40	25	239	1,134464014	1,029744259	0,776857399	0,466783018	0,422618262	joint
40	87	329	0,052359878	2,600540585	0,02695501	-0,04486067	0,998629535	joint
40	40	264	0,872664626	1,466076572	0,761847972	0,080073448	0,64278761	joint
40	56	285	0,593411946	1,832595715	0,540138867	-0,144729773	0,829037573	joint
40	87	211	0,052359878	0,541052068	0,02695501	0,04486067	0,998629535	joint
41 - 50	50	247	0,698131701	1,169370599	0,591689114	0,251157128	0,766044443	foliation
50	50	247	0,698131701	1,169370599	0,591689114	0,251157128	0,766044443	foliation
50	49	272	0,715584993	1,605702912	0,655659376	-0,02289613	0,75470958	foliation
50	74	240	0,27925268	1,047197551	0,238708952	0,137818678	0,961261696	joint
50	59	278	0,541052068	1,710422667	0,51002576	-0,071679446	0,857167301	joint
50	52	305	0,663225116	2,181661565	0,504320356	-0,353128915	0,788010754	joint
50	48	261	0,733038286	1,413716694	0,660892498	0,104675088	0,743144825	joint
50	66	164	0,41887902	-0,27925268	-0,112111813	0,390980355	0,913545458	joint
50	52	281	0,663225116	1,762782545	0,60435004	-0,117473748	0,788010754	joint
50	56	51	0,593411946	-2,251474735	-0,434574507	-0,351911497	0,829037573	joint
50	58	265	0,558505361	1,483529864	0,527902761	0,046185507	0,848048096	foliation
50	36	272	0,942477796	1,605702912	0,808524163	-0,028234286	0,587785252	joint
50	82	42	0,13962634	-2,408554368	-0,093124981	-0,10342577	0,990268069	joint
50	80	171	0,174532925	-0,157079633	-0,02716456	0,17151028	0,984807753	joint
50	81	165	0,157079633	-0,261799388	-0,040488219	0,15110409	0,987688341	joint
50	79	165	0,191986218	-0,261799388	-0,049385002	0,184307337	0,981627183	joint
50	35	112	0,959931089	-1,186823891	-0,75950455	0,306859757	0,573576436	joint
50	88	181	0,034906585	0,017453293	0,00060908	0,034894181	0,999390827	joint
50	89	185	0,017453293	0,087266463	0,001521077	0,017385995	0,999847695	joint
50	20	221	1,221730476	0,715584993	0,616493828	0,709195023	0,342020143	joint
50	86	184	0,06981317	0,06981317	0,004865966	0,06958655	0,99756405	joint
50	70	234	0,34906585	0,942477796	0,276700108	0,201034396	0,939692621	joint
50	88	175	0,034906585	-0,087266463	-0,003041692	0,034766694	0,999390827	joint
50	39	273	0,890117919	1,623156204	0,77608091	-0,040672677	0,629320391	joint
50	59	344	0,541052068	2,862339973	0,141963733	-0,495086373	0,857167301	joint
50	38	251	0,907571211	1,239183769	0,745078805	0,256551207	0,615661475	joint
50	70	241	0,34906585	1,064650844	0,299137558	0,165814656	0,939692621	joint
50	40	229	0,872664626	0,855211333	0,57814108	0,502570374	0,64278761	joint
50	88	225	0,034906585	0,785398163	0,024677671	0,024677671	0,999390827	joint
50	50	290	0,698131701	1,919862177	0,604022774	-0,21984631	0,766044443	foliation
50	43	264	0,820304748	1,466076572	0,72734727	0,076447279	0,68199836	foliation
50	53	280	0,645771823	1,745329252	0,592672101	-0,104504082	0,79863551	foliation
50	74	250	0,27925268	1,221730476	0,259014389	0,094273528	0,961261696	foliation
50	60	260	0,523598776	1,396263402	0,492403877	0,086824089	0,866025404	foliation
50	40	285	0,872664626	1,832595715	0,739942112	-0,198266891	0,64278761	foliation
50	68	280	0,383972435	1,745329252	0,368915478	-0,065049752	0,927183855	foliation
50	45	288	0,785398163	1,884955592	0,672498512	-0,218508012	0,707106781	foliation
50	41	276	0,855211333	1,675516082	0,750575202	-0,078888633	0,656059029	joint
50	78	358	0,20943951	3,106686069	0,007256013	-0,207785037	0,978147601	joint
50	78	153	0,20943951	-0,471238898	-0,094389932	0,185250673	0,978147601	joint
50	85	347	0,087266463	2,914699851	0,019605776	-0,084921947	0,996194698	joint
50	75	58	0,261799388	-2,129301687	-0,219490998	-0,137153198	0,965925826	joint
50	70	20	0,34906585	-2,792526803	-0,116977778	-0,321393805	0,939692621	joint
50	75	218	0,261799388	0,663225116	0,159344915	0,203952191	0,965925826	joint
50	80	211	0,174532925	0,541052068	0,089435423	0,14884554	0,984807753	joint

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
50	55	292	0,610865238	1,954768762	0,531810811	-0,214865515	0,819152044	joint
50	58	8	0,558505361	-3,001966313	-0,073750507	-0,524762126	0,848048096	joint
50	82	48	0,13962634	-2,303834613	-0,10342577	-0,093124981	0,990268069	joint
50	76	301	0,244346095	2,111848395	0,207367538	-0,124598987	0,970295726	joint
50	79	225	0,191986218	0,785398163	0,134922335	0,134922335	0,981627183	joint
50	81	43	0,157079633	-2,391101075	-0,106688049	-0,114408925	0,987688341	joint
50	80	158	0,174532925	-0,383972435	-0,065049752	0,161003787	0,984807753	joint
50	69	53	0,366519143	-2,21656815	-0,28620537	-0,215671216	0,933580426	joint
50	84	43	0,104719755	-2,391101075	-0,071288241	-0,076447279	0,994521895	joint
50	70	220	0,34906585	0,698131701	0,21984631	0,26200263	0,939692621	joint
50	72	108	0,314159265	-1,256637061	-0,293892626	0,095491503	0,951056516	joint
50	82	52	0,13962634	-2,234021443	-0,1096699	-0,085683517	0,990268069	joint
50	72	108	0,314159265	-1,256637061	-0,293892626	0,095491503	0,951056516	joint
50	86	220	0,06981317	0,698131701	0,044838597	0,053436559	0,99756405	joint
50	72	8	0,314159265	-3,001966313	-0,043006853	-0,306009662	0,951056516	joint
50	72	37	0,314159265	-2,49582083	-0,18597107	-0,246791945	0,951056516	joint
50	79	228	0,191986218	0,837758041	0,141798718	0,127676139	0,981627183	joint
50	87	351	0,052359878	2,984513021	0,008187147	-0,051691614	0,998629535	joint
50	18	310	1,256637061	2,268928028	0,728551559	-0,611327345	0,309016994	joint
50	55	228	0,610865238	0,837758041	0,426250361	0,383797549	0,819152044	joint
50	84	353	0,104719755	3,019419606	0,012738815	-0,103749324	0,994521895	joint
50	55	228	0,610865238	0,837758041	0,426250361	0,383797549	0,819152044	joint
50	35	321	0,959931089	2,460914245	0,515509085	-0,636600703	0,573576436	joint
50	33	269	0,994837674	1,553343034	0,838542834	0,01463682	0,544639035	foliation
50	80	264	0,174532925	1,466076572	0,172696915	0,018151177	0,984807753	foliation
50	57	265	0,575958653	1,483529864	0,542566519	0,04746842	0,838670568	foliation
50	78	48	0,20943951	-2,303834613	-0,154508497	-0,139120076	0,978147601	joint
50	79	218	0,191986218	0,663225116	0,117473748	0,15035954	0,981627183	joint
50	80	224	0,174532925	0,767944871	0,12062616	0,124912045	0,984807753	joint
50	77	359	0,226892803	3,124139361	0,003925937	-0,224916793	0,974370065	joint
50	67	5	0,401425728	-3,054326191	-0,034054462	-0,389244279	0,920504853	joint
50	51	255	0,680678408	1,308996939	0,607876819	0,162880103	0,777145961	foliation
50	88	227	0,034906585	0,820304748	0,025523876	0,0238014	0,999390827	joint
50	62	110	0,488692191	-1,221730476	-0,441158963	0,160568731	0,882947593	joint
50	68	43	0,383972435	-2,391101075	-0,255481082	-0,273969919	0,927183855	joint
50	44	273	0,802851456	1,623156204	0,71835397	-0,037647336	0,69465837	foliation
50	27	275	1,099557429	1,658062789	0,887615975	-0,077656335	0,4539905	foliation
50	74	240	0,27925268	1,047197551	0,238708952	0,137818678	0,961261696	joint
50	62	270	0,488692191	1,570796327	0,469471563	2,87586E-17	0,882947593	foliation
50	59	273	0,541052068	1,623156204	0,514332233	-0,02695501	0,857167301	foliation
50	85	283	0,087266463	1,79768913	0,084921947	-0,019605776	0,996194698	foliation
50	52	277	0,663225116	1,692969374	0,611072428	-0,07503026	0,788010754	foliation
50	76	226	0,244346095	0,802851456	0,174024048	0,16805307	0,970295726	joint
50	29	122	1,064650844	-1,012290966	-0,741719578	0,463477832	0,48480962	joint
50	27	114	1,099557429	-1,151917306	-0,813974963	0,362405003	0,4539905	joint
50	87	178	0,052359878	-0,034906585	-0,001826499	0,052304075	0,998629535	joint
50	61	288	0,506145483	1,884955592	0,461081348	-0,149814412	0,874619707	joint
50	82	243	0,13962634	1,099557429	0,124004141	0,063183266	0,990268069	joint
50	44	110	0,802851456	-1,221730476	-0,675958302	0,246028702	0,69465837	joint
50	52	272	0,663225116	1,605702912	0,615286431	-0,021486276	0,788010754	joint
50	78	18	0,20943951	-2,827433388	-0,064248246	-0,197735768	0,978147601	joint
50	53	291	0,645771823	1,93731547	0,561842726	-0,215671216	0,79863551	joint
50	84	311	0,104719755	2,28638132	0,078888633	-0,068576842	0,994521895	joint
50	83	316	0,122173048	2,373647783	0,084657559	-0,087665469	0,992546152	joint
50	87	225	0,052359878	0,785398163	0,03700711	0,03700711	0,998629535	joint
50	88	221	0,034906585	0,715584993	0,02289613	0,026338985	0,999390827	joint
50	55	278	0,610865238	1,710422667	0,56799443	-0,079826411	0,819152044	joint

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
50	57	290	0,575958653	1,919862177	0,511793282	-0,186277521	0,838670568	joint
50	89	25	0,017453293	-2,705260341	-0,007375706	-0,015817252	0,999847695	joint
50	67	271	0,401425728	1,588249619	0,390671618	-0,006819198	0,920504853	joint
50	30	268	1,047197551	1,535889742	0,865497845	0,030223851	0,5	foliation
50	48	283	0,733038286	1,79768913	0,651980832	-0,150521635	0,743144825	foliation
50	32	244	1,012290966	1,117010721	0,76222058	0,371759816	0,529919264	foliation
50	49	278	0,715584993	1,710422667	0,649674308	-0,091305769	0,75470958	foliation
50	83	215	0,122173048	0,610865238	0,069901384	0,099829522	0,992546152	joint
50	83	139	0,122173048	-0,715584993	-0,079953483	0,091975961	0,992546152	joint
50	80	300	0,174532925	2,094395102	0,150383733	-0,086824089	0,984807753	joint
50	36	272	0,942477796	1,605702912	0,808524163	-0,028234286	0,587785252	joint
50	85	184	0,087266463	0,06981317	0,006079677	0,086943436	0,996194698	joint
50	88	186	0,034906585	0,104719755	0,003647991	0,034708314	0,999390827	joint
50	75	174	0,261799388	-0,104719755	-0,027053957	0,257401207	0,965925826	joint
50	88	182	0,034906585	0,034906585	0,001217975	0,034878237	0,999390827	joint
50	41	268	0,855211333	1,535889742	0,754249832	0,026338985	0,656059029	foliation
50	31	202	1,029744259	0,383972435	0,321100523	0,794751682	0,515038075	joint
50	43	157	0,820304748	-0,401425728	-0,285762657	0,673214632	0,68199836	joint
50	30	241	1,047197551	1,064650844	0,757442885	0,419857447	0,5	joint
50	25	210	1,134464014	0,523598776	0,453153894	0,784885567	0,422618262	joint
50	87	127	0,052359878	-0,925024504	-0,041797353	0,031496565	0,998629535	joint
50	29	245	1,064650844	1,134464014	0,792674651	0,36963026	0,48480962	joint
50	78	335	0,20943951	2,705260341	0,087867277	-0,188431984	0,978147601	joint
50	67	222	0,401425728	0,733038286	0,261450157	0,290369816	0,920504853	joint
50	88	130	0,034906585	-0,872664626	-0,026734566	0,022432964	0,999390827	joint
50	38	161	0,907571211	-0,331612558	-0,256551207	0,745078805	0,615661475	joint
50	49	258	0,715584993	1,361356817	0,641722565	0,136402342	0,75470958	foliation
50	52	261	0,663225116	1,413716694	0,608081661	0,096310674	0,788010754	foliation
50	50	284	0,698131701	1,815142422	0,623694071	-0,155504397	0,766044443	foliation
50	42	28	0,837758041	-2,652900463	-0,348885363	-0,656157935	0,669130606	foliation
50	53	275	0,645771823	1,658062789	0,599524935	-0,052451635	0,79863551	foliation
50	47	286	0,750491578	1,850049007	0,6555789	-0,187984225	0,731353702	foliation
50	52	291	0,663225116	1,93731547	0,574769503	-0,220633341	0,788010754	foliation
50	44	264	0,802851456	1,466076572	0,715399182	0,075191484	0,69465837	foliation
50	47	275	0,750491578	1,658062789	0,67940315	-0,059440074	0,731353702	foliation
50	83	291	0,122173048	1,93731547	0,113774834	-0,043674067	0,992546152	foliation
50	74	68	0,27925268	-1,954768762	-0,255566506	-0,103255571	0,961261696	foliation
50	87	11	0,052359878	-2,949606436	-0,009986171	-0,051374397	0,998629535	foliation
50	84	234	0,104719755	0,942477796	0,084565303	0,061440289	0,994521895	foliation
50	89	175	0,017453293	-0,087266463	-0,001521077	0,017385995	0,999847695	foliation
50	59	269	0,541052068	1,553343034	0,514959632	0,008988654	0,857167301	foliation
50	47	271	0,750491578	1,588249619	0,681894488	-0,011902513	0,731353702	foliation
50	41	263	0,855211333	1,448623279	0,749084089	0,091975961	0,656059029	foliation
50	43	262	0,820304748	1,431169987	0,724236218	0,101784763	0,68199836	foliation
50	40	256	0,872664626	1,326450232	0,743289649	0,185322924	0,64278761	foliation
50	35	275	0,959931089	1,658062789	0,816034923	-0,071393805	0,573576436	foliation
50	75	262	0,261799388	1,431169987	0,256300236	0,036020649	0,965925826	foliation
50	65	285	0,436332313	1,832595715	0,408217894	-0,109381655	0,906307787	foliation
50	58	232	0,558505361	0,907571211	0,417582079	0,326250876	0,848048096	foliation
50	38	262	0,907571211	1,431169987	0,780341887	0,1096699	0,615661475	foliation
50	38	262	0,907571211	1,431169987	0,780341887	0,1096699	0,615661475	foliation
50	43	257	0,820304748	1,343903524	0,712609154	0,164518786	0,68199836	foliation
50	75	262	0,261799388	1,431169987	0,256300236	0,036020649	0,965925826	foliation
50	65	285	0,436332313	1,832595715	0,408217894	-0,109381655	0,906307787	foliation
50	36	265	0,942477796	1,483529864	0,80593844	0,070510477	0,587785252	foliation
50	45	260	0,785398163	1,396263402	0,69636424	0,122787804	0,707106781	foliation
50	58	232	0,558505361	0,907571211	0,417582079	0,326250876	0,848048096	foliation

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
50	38	262	0,907571211	1,431169987	0,780341887	0,1096699	0,615661475	foliation
50	43	257	0,820304748	1,343903524	0,712609154	0,164518786	0,68199836	foliation
50	38	262	0,907571211	1,431169987	0,780341887	0,1096699	0,615661475	foliation
50	40	260	0,872664626	1,396263402	0,754406507	0,133022222	0,64278761	foliation
50	45	285	0,785398163	1,832595715	0,683012702	-0,183012702	0,707106781	foliation
50	16	240	1,291543646	1,047197551	0,832477048	0,480630848	0,275637356	foliation
50	50	260	0,698131701	1,396263402	0,633022222	0,111618897	0,766044443	foliation
50	45	275	0,785398163	1,658062789	0,704416026	-0,061628417	0,707106781	foliation
50	72	172	0,314159265	-0,13962634	-0,043006853	0,306009662	0,951056516	joint
50	77	22	0,226892803	-2,757620218	-0,084268148	-0,208570986	0,974370065	joint
50	82	196	0,13962634	0,27925268	0,038361306	0,133781771	0,990268069	joint
50	86	208	0,06981317	0,488692191	0,032748681	0,061591311	0,99756405	joint
50	84	209	0,104719755	0,506145483	0,050676405	0,091422654	0,994521895	joint
50	80	221	0,174532925	0,715584993	0,113923455	0,131053943	0,984807753	joint
50	78	174	0,20943951	-0,104719755	-0,02173269	0,206772729	0,978147601	joint
50	66	209	0,41887902	0,506145483	0,197189837	0,355739884	0,913545458	joint
50	66	78	0,41887902	-1,780235837	-0,397848472	-0,084565303	0,913545458	joint
50	87	12	0,052359878	-2,932153143	-0,010881257	-0,05119229	0,998629535	joint
50	72	208	0,314159265	0,488692191	0,145074691	0,272845811	0,951056516	joint
50	80	333	0,174532925	2,670353756	0,078834623	-0,154721659	0,984807753	joint
50	67	193	0,401425728	0,226892803	0,087895379	0,380716715	0,920504853	joint
50	72	18	0,314159265	-2,827433388	-0,095491503	-0,293892626	0,951056516	joint
50	28	260	1,082104136	1,396263402	0,869533635	0,15332224	0,469471563	joint
50	87	130	0,052359878	-0,872664626	-0,040091668	0,033640904	0,998629535	joint
50	58	75	0,558505361	-1,832595715	-0,511862703	-0,137153198	0,848048096	joint
50	71	205	0,331612558	0,436332313	0,137591048	0,295064954	0,945518576	joint
50	87	85	0,052359878	-1,658062789	-0,052136802	-0,004561379	0,998629535	joint
50	87	2	0,052359878	-3,106686069	-0,001826499	-0,052304075	0,998629535	joint
50	84	73	0,104719755	-1,8675023	-0,099961067	-0,030561165	0,994521895	joint
50	84	75	0,104719755	-1,832595715	-0,100966742	-0,027053957	0,994521895	joint
50	86	5	0,06981317	-3,054326191	-0,006079677	-0,069491029	0,99756405	joint
50	88	57	0,034906585	-2,14675498	-0,029269181	-0,019007628	0,999390827	joint
50	88	253	0,034906585	1,274090354	0,033374555	0,010203625	0,999390827	joint
50	64	60	0,453785606	-2,094395102	-0,379640549	-0,219185573	0,898794046	joint
50	83	25	0,122173048	-2,705260341	-0,05150421	-0,110451135	0,992546152	joint
50	65	59	0,436332313	-2,111848395	-0,362254555	-0,217664496	0,906307787	joint
50	87	255	0,052359878	1,308996939	0,050552652	0,013545542	0,998629535	joint
50	74	240	0,27925268	1,047197551	0,238708952	0,137818678	0,961261696	joint
50	85	69	0,087266463	-1,93731547	-0,081366895	-0,031233825	0,996194698	joint
50	79	32	0,191986218	-2,583087293	-0,101113362	-0,161815205	0,981627183	joint
50	87	55	0,052359878	-2,181661565	-0,042871106	-0,030018671	0,998629535	joint
50	88	171	0,034906585	-0,157079633	-0,005459484	0,034469826	0,999390827	joint
50	18	221	1,256637061	0,715584993	0,623949215	0,717771464	0,309016994	joint
50	81	158	0,157079633	-0,383972435	-0,058601382	0,14504351	0,987688341	joint
50	38	214	0,907571211	0,593411946	0,440650021	0,653290522	0,615661475	joint
50	82	156	0,13962634	-0,41887902	-0,0566068	0,127140954	0,990268069	joint
50	84	45	0,104719755	-2,35619449	-0,073912785	-0,073912785	0,994521895	joint
50	85	43	0,087266463	-2,391101075	-0,059440074	-0,063741675	0,996194698	joint
50	21	138	1,204277184	-0,733038286	-0,624687237	0,693785463	0,35836795	joint
50	87	50	0,052359878	-2,268928028	-0,040091668	-0,033640904	0,998629535	joint
50	83	52	0,122173048	-2,234021443	-0,096034353	-0,07503026	0,992546152	joint
50	87	48	0,052359878	-2,303834613	-0,038893195	-0,03501959	0,998629535	joint
50	39	146	0,890117919	-0,593411946	-0,434574507	0,644283201	0,629320391	joint
50	88	51	0,034906585	-2,251474735	-0,027122003	-0,021962965	0,999390827	joint
50	87	265	0,052359878	1,483529864	0,052136802	0,004561379	0,998629535	joint
50	87	68	0,052359878	-1,954768762	-0,048525054	-0,019605394	0,998629535	joint
50	83	261	0,122173048	1,413716694	0,12036893	0,019064566	0,992546152	joint

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
50	83	271	0,122173048	1,588249619	0,121850782	-0,002126913	0,992546152	joint
50	83	261	0,122173048	1,413716694	0,12036893	0,019064566	0,992546152	joint
50	87	64	0,052359878	-2,024581932	-0,047039246	-0,022942573	0,998629535	joint
50	82	256	0,13962634	1,326450232	0,135039065	0,03366902	0,990268069	joint
50	87	172	0,052359878	-0,13962634	-0,007283757	0,051826626	0,998629535	joint
50	87	248	0,052359878	1,186823891	0,048525054	0,019605394	0,998629535	joint
50	85	170	0,087266463	-0,174532925	-0,015134436	0,085831651	0,996194698	joint
50	70	124	0,34906585	-0,977384381	-0,283547549	0,191255237	0,939692621	joint
50	38	256	0,907571211	1,326450232	0,764603466	0,190637055	0,615661475	joint
50	76	226	0,244346095	0,802851456	0,174024048	0,16805307	0,970295726	joint
50	74	75	0,27925268	-1,832595715	-0,266245241	-0,071340197	0,961261696	joint
50	70	242	0,34906585	1,082104136	0,301985862	0,160568731	0,939692621	joint
50	78	238	0,20943951	1,012290966	0,176319114	0,11017641	0,978147601	joint
50	75	235	0,261799388	0,959931089	0,21201215	0,148452506	0,965925826	joint
50	80	240	0,174532925	1,047197551	0,150383733	0,086824089	0,984807753	joint
50	70	234	0,34906585	0,942477796	0,276700108	0,201034396	0,939692621	joint
50	83	237	0,122173048	0,994837674	0,102208231	0,066374802	0,992546152	joint
50	80	280	0,174532925	1,745329252	0,171010072	-0,03015369	0,984807753	joint
50	36	365	0,942477796	3,228859116	-0,070510477	-0,80593844	0,587785252	joint
50	85	78	0,087266463	-1,780235837	-0,085251181	-0,018120698	0,996194698	joint
50	61	43	0,506145483	-2,391101075	-0,330639366	-0,35456731	0,874619707	joint
50	60	145	0,523598776	-0,610865238	-0,286788218	0,409576022	0,866025404	joint
50	81	355	0,157079633	3,054326191	0,013634162	-0,155839185	0,987688341	joint
50	76	83	0,244346095	-1,692969374	-0,240118646	-0,029482863	0,970295726	joint
50	78	5	0,20943951	-3,054326191	-0,018120698	-0,207120524	0,978147601	joint
50	66	50	0,41887902	-2,268928028	-0,311578345	-0,261445275	0,913545458	joint
50	75	38	0,261799388	-2,478367538	-0,159344915	-0,203952191	0,965925826	joint
50	88	345	0,034906585	2,879793266	0,009032654	-0,033710325	0,999390827	joint
50	85	76	0,087266463	-1,815142422	-0,084566845	-0,021084882	0,996194698	joint
50	60	145	0,523598776	-0,610865238	-0,286788218	0,409576022	0,866025404	joint
50	74	219	0,27925268	0,680678408	0,173464209	0,214210458	0,961261696	joint
50	61	43	0,506145483	-2,391101075	-0,330639366	-0,35456731	0,874619707	joint
50	87	32	0,052359878	-2,583087293	-0,027733831	-0,044383408	0,998629535	joint
50	45	253	0,785398163	1,274090354	0,676209578	0,206738015	0,707106781	joint
50	75	58	0,261799388	-2,129301687	-0,219490998	-0,137153198	0,965925826	joint
50	77	51	0,226892803	-2,251474735	-0,174819803	-0,141566285	0,974370065	joint
50	62	55	0,488692191	-2,181661565	-0,38456859	-0,269277826	0,882947593	joint
50	31	83	1,029744259	-1,692969374	-0,850778106	-0,104462416	0,515038075	joint
50	53	125	0,645771823	-0,959931089	-0,492978006	0,345186916	0,79863551	joint
50	77	60	0,226892803	-2,094395102	-0,194813328	-0,112475527	0,974370065	joint
50	81	41	0,157079633	-2,42600766	-0,102630243	-0,118062589	0,987688341	joint
50	77	83	0,226892803	-1,692969374	-0,223274303	-0,027414637	0,974370065	joint
50	56	289	0,593411946	1,902408885	0,528727278	-0,182055402	0,829037573	foliation
50	41	262	0,855211333	1,431169987	0,747364798	0,105035273	0,656059029	foliation
50	47	266	0,750491578	1,500983157	0,680337046	0,047573801	0,731353702	foliation
50	45	270	0,785398163	1,570796327	0,707106781	4,33155E-17	0,707106781	foliation
50	54	285	0,628318531	1,832595715	0,567756956	-0,152130018	0,809016994	foliation
50	44	282	0,802851456	1,780235837	0,7036205	-0,149559154	0,69465837	foliation
50	54	262	0,628318531	1,431169987	0,582064967	0,081803896	0,809016994	foliation
50	41	286	0,855211333	1,850049007	0,725473411	-0,208026153	0,656059029	foliation
50	46	291	0,767944871	1,93731547	0,648519458	-0,248943296	0,7193398	foliation
50	46	252	0,767944871	1,256637061	0,66065937	0,214661242	0,7193398	foliation
50	47	258	0,750491578	1,361356817	0,66709506	0,141795432	0,731353702	foliation
50	64	273	0,453785606	1,623156204	0,437770374	-0,022942573	0,898794046	foliation
50	54	272	0,628318531	1,605702912	0,587427189	-0,020513409	0,809016994	foliation
50	58	264	0,558505361	1,466076572	0,527016311	0,055391646	0,848048096	foliation
50	63	294	0,471238898	1,989675347	0,414740959	-0,184654572	0,891006524	foliation

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
50	58	285	0,558505361	1,832595715	0,511862703	-0,137153198	0,848048096	foliation
50	53	274	0,645771823	1,640609497	0,600349032	-0,041980494	0,79863551	foliation
50	57	287	0,575958653	1,8675023	0,520840899	-0,159237043	0,838670568	foliation
50	58	288	0,558505361	1,884955592	0,503983169	-0,163754058	0,848048096	foliation
50	58	295	0,558505361	2,00712864	0,480269956	-0,223953558	0,848048096	foliation
50	57	291	0,575958653	1,93731547	0,508464343	-0,195181174	0,838670568	foliation
50	54	292	0,628318531	1,954768762	0,544984996	-0,220188231	0,809016994	foliation
50	56	292	0,593411946	1,954768762	0,518474632	-0,209477349	0,829037573	foliation
50	57	289	0,575958653	1,902408885	0,514966325	-0,177317125	0,838670568	foliation
50	50	278	0,698131701	1,710422667	0,636532045	-0,089458745	0,766044443	foliation
50	52	275	0,663225116	1,658062789	0,613318698	-0,053658433	0,788010754	foliation
50	40	288	0,872664626	1,884955592	0,728551559	-0,236720751	0,64278761	foliation
50	57	268	0,575958653	1,535889742	0,544307256	0,019007628	0,838670568	foliation
50	54	265	0,628318531	1,483529864	0,585548552	0,05122886	0,809016994	foliation
50	53	75	0,645771823	-1,832595715	-0,581308674	-0,15576119	0,79863551	joint
50	85	62	0,087266463	-2,059488517	-0,076953953	-0,040917143	0,996194698	joint
50	87	210	0,052359878	0,523598776	0,026167978	0,045324268	0,998629535	joint
50	78	200	0,20943951	0,34906585	0,071109986	0,195373082	0,978147601	joint
50	81	343	0,157079633	2,844886681	0,045737011	-0,149599023	0,987688341	joint
50	75	224	0,261799388	0,767944871	0,179790816	0,18617884	0,965925826	joint
50	88	55	0,034906585	-2,181661565	-0,028587994	-0,020017529	0,999390827	joint
50	63	56	0,471238898	-2,164208272	-0,376375182	-0,253868266	0,891006524	joint
50	68	59	0,383972435	-2,111848395	-0,321100523	-0,192936659	0,927183855	joint
50	33	270	0,994837674	1,570796327	0,838670568	5,13748E-17	0,544639035	joint
50	61	54	0,506145483	-2,199114858	-0,392219222	-0,284963945	0,874619707	joint
50	63	58	0,471238898	-2,129301687	-0,385005779	-0,240578312	0,891006524	joint
50	71	33	0,331612558	-2,565634	-0,177317125	-0,273044429	0,945518576	joint
50	89	45	0,017453293	-2,35619449	-0,012340715	-0,012340715	0,999847695	joint
50	77	49	0,226892803	-2,28638132	-0,169772716	-0,14758117	0,974370065	joint
50	69	312	0,366519143	2,303834613	0,266319287	-0,239794963	0,933580426	joint
50	84	314	0,104719755	2,338741198	0,075191484	-0,072611572	0,994521895	joint
50	44	143	0,802851456	-0,645771823	-0,432909499	0,574490308	0,69465837	joint
50	63	348	0,471238898	2,932153143	0,094389932	-0,444069718	0,891006524	joint
50	71	35	0,331612558	-2,530727415	-0,186738222	-0,266689819	0,945518576	joint
50	63	348	0,471238898	2,932153143	0,094389932	-0,444069718	0,891006524	joint
50	39	142	0,890117919	-0,663225116	-0,478458829	0,612399375	0,629320391	joint
50	85	214	0,087266463	0,593411946	0,048736873	0,072255385	0,996194698	joint
50	29	301	1,064650844	2,111848395	0,749695414	-0,45046245	0,48480962	joint
50	87	339	0,052359878	2,775073511	0,018755529	-0,048859824	0,998629535	joint
50	46	309	0,767944871	2,251474735	0,539850947	-0,437162677	0,7193398	joint
50	71	14	0,331612558	-2,897246558	-0,078762065	-0,315897389	0,945518576	joint
50	67	90	0,401425728	-1,570796327	-0,390731128	2,39352E-17	0,920504853	joint
50	69	172	0,366519143	-0,13962634	-0,049875179	0,354880337	0,933580426	joint
50	64	355	0,453785606	3,054326191	0,038206563	-0,436703012	0,898794046	joint
50	57	73	0,575958653	-1,8675023	-0,520840899	-0,159237043	0,838670568	joint
50	87	196	0,052359878	0,27925268	0,014425745	0,05030855	0,998629535	joint
50	81	330	0,157079633	2,617993878	0,078217233	-0,135476221	0,987688341	joint
50	85	83	0,087266463	-1,692969374	-0,086506097	-0,010621613	0,996194698	joint
50	62	65	0,488692191	-2,00712864	-0,425485733	-0,198407256	0,882947593	joint
50	76	83	0,244346095	-1,692969374	-0,240118646	-0,029482863	0,970295726	joint
50	66	50	0,41887902	-2,268928028	-0,311578345	-0,261445275	0,913545458	joint
50	35	100	0,959931089	-1,396263402	-0,806707284	0,14224426	0,573576436	joint
50	49	262	0,715584993	1,431169987	0,649674308	0,091305769	0,75470958	foliation
50	46	258	0,767944871	1,361356817	0,679478418	0,144427596	0,7193398	foliation
50	46	281	0,767944871	1,762782545	0,68189554	-0,132547066	0,7193398	foliation
50	45	287	0,785398163	1,8675023	0,676209578	-0,206738015	0,707106781	foliation
50	41	287	0,855211333	1,8675023	0,721732361	-0,220655727	0,656059029	foliation

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
50	43	295	0,820304748	2,00712864	0,662831555	-0,30908343	0,68199836	foliation
50	39	300	0,890117919	2,094395102	0,673028145	-0,388572981	0,629320391	foliation
50	40	296	0,872664626	2,024581932	0,688516185	-0,335811781	0,64278761	foliation
50	89	194	0,017453293	0,244346095	0,004222119	0,016933995	0,999847695	foliation
50	41	285	0,855211333	1,832595715	0,728993475	-0,195333213	0,656059029	foliation
50	43	280	0,820304748	1,745329252	0,720242796	-0,126998238	0,68199836	foliation
50	50	261	0,698131701	1,413716694	0,634873828	0,100554136	0,766044443	foliation
50	51	286	0,680678408	1,850049007	0,604941586	-0,173464209	0,777145961	foliation
50	52	280	0,663225116	1,745329252	0,606308194	-0,106908493	0,788010754	foliation
50	40	246	0,872664626	1,151917306	0,699816421	0,311578345	0,64278761	foliation
50	51	276	0,680678408	1,675516082	0,625872908	-0,065781893	0,777145961	foliation
50	53	274	0,645771823	1,640609497	0,600349032	-0,041980494	0,79863551	foliation
50	49	281	0,715584993	1,762782545	0,644005377	-0,125181964	0,75470958	foliation
50	41	285	0,855211333	1,832595715	0,728993475	-0,195333213	0,656059029	foliation
50	35	252	0,959931089	1,256637061	0,77905989	0,253131903	0,573576436	foliation
50	58	267	0,558505361	1,518436449	0,529193028	0,027733831	0,848048096	foliation
50	57	246	0,575958653	1,151917306	0,497552516	0,221524653	0,838670568	foliation
50	40	291	0,872664626	1,93731547	0,715164098	-0,274525776	0,64278761	foliation
50	49	273	0,715584993	1,623156204	0,655159923	-0,034335477	0,75470958	foliation
50	48	275	0,733038286	1,658062789	0,666584362	-0,058318575	0,743144825	foliation
50	55	289	0,610865238	1,902408885	0,542327175	-0,186738222	0,819152044	foliation
50	49	273	0,715584993	1,623156204	0,655159923	-0,034335477	0,75470958	foliation
50	48	274	0,733038286	1,640609497	0,667500638	-0,046676192	0,743144825	foliation
50	49	284	0,715584993	1,815142422	0,636571272	-0,158715044	0,75470958	foliation
50	51	277	0,680678408	1,692969374	0,624629532	-0,076694863	0,777145961	foliation
50	48	276	0,733038286	1,675516082	0,665465039	-0,069943194	0,743144825	foliation
50	46	272	0,767944871	1,605702912	0,694235203	-0,024243228	0,7193398	foliation
50	43	268	0,820304748	1,535889742	0,730908181	0,025523876	0,68199836	foliation
50	49	278	0,715584993	1,710422667	0,649674308	-0,091305769	0,75470958	foliation
50	51	262	0,680678408	1,431169987	0,623195888	0,08758447	0,777145961	foliation
50	45	282	0,785398163	1,780235837	0,691654801	-0,147015766	0,707106781	foliation
50	45	275	0,785398163	1,658062789	0,704416026	-0,061628417	0,707106781	foliation
50	45	260	0,785398163	1,396263402	0,69636424	0,122787804	0,707106781	foliation
50	41	286	0,855211333	1,850049007	0,725473411	-0,208026153	0,656059029	joint
50	28	260	1,082104136	1,396263402	0,869533635	0,15332224	0,469471563	joint
50	60	228	0,523598776	0,837758041	0,371572413	0,334565303	0,866025404	joint
50	61	195	0,506145483	0,261799388	0,125477963	0,468290133	0,874619707	joint
50	88	75	0,034906585	-1,832595715	-0,033710325	-0,009032654	0,999390827	joint
50	86	47	0,06981317	-2,321287905	-0,051016655	-0,047573801	0,99756405	joint
50	46	282	0,767944871	1,780235837	0,679478418	-0,144427596	0,7193398	joint
50	52	41	0,663225116	-2,42600766	-0,40391027	-0,464645614	0,788010754	joint
50	53	72	0,645771823	-1,884955592	-0,572360099	-0,18597107	0,79863551	joint
50	87	250	0,052359878	1,221730476	0,049179712	0,017899951	0,998629535	joint
50	52	198	0,663225116	0,314159265	0,190249859	0,585528858	0,788010754	joint
50	63	57	0,471238898	-2,14675498	-0,38074847	-0,247260948	0,891006524	joint
50	83	217	0,122173048	0,645771823	0,073342802	0,097329185	0,992546152	joint
50	87	47	0,052359878	-2,321287905	-0,038276095	-0,035693036	0,998629535	joint
50	87	54	0,052359878	-2,199114858	-0,042340678	-0,030762303	0,998629535	joint
50	55	127	0,610865238	-0,925024504	-0,45807851	0,345186916	0,819152044	joint
50	44	80	0,802851456	-1,745329252	-0,708411412	-0,124912045	0,69465837	joint
50	70	169	0,34906585	-0,191986218	-0,06526052	0,33573627	0,939692621	joint
50	85	300	0,087266463	2,094395102	0,075479087	-0,043577871	0,996194698	joint
50	59	264	0,541052068	1,466076572	0,512216642	0,053836138	0,857167301	joint
50	65	319	0,436332313	2,42600766	0,277262526	-0,318954051	0,906307787	joint
50	87	66	0,052359878	-1,989675347	-0,047811275	-0,021286951	0,998629535	joint
50	22	286	1,186823891	1,850049007	0,891266324	-0,255566506	0,374606593	joint
50	52	193	0,663225116	0,226892803	0,138493698	0,599882112	0,788010754	joint

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
50	51	204	0,680678408	0,41887902	0,255967663	0,574912785	0,777145961	joint
50	89	230	0,017453293	0,872664626	0,013369319	0,011218191	0,999847695	joint
50	85	210	0,087266463	0,523598776	0,043577871	0,075479087	0,996194698	joint
50	87	200	0,052359878	0,34906585	0,017899951	0,049179712	0,998629535	joint
50	84	268	0,104719755	1,535889742	0,104464787	0,003647991	0,994521895	joint
50	57	338	0,575958653	2,757620218	0,204025374	-0,50498052	0,838670568	joint
50	78	45	0,20943951	-2,35619449	-0,147015766	-0,147015766	0,978147601	joint
50	88	345	0,034906585	2,879793266	0,009032654	-0,033710325	0,999390827	joint
50	37	265	0,925024504	1,483529864	0,795596461	0,069605671	0,601815023	foliation
50	87	53	0,052359878	-2,21656815	-0,041797353	-0,031496565	0,998629535	joint
50	68	269	0,383972435	1,553343034	0,374549539	0,006537787	0,927183855	foliation
50	89	85	0,017453293	-1,658062789	-0,017385995	-0,001521077	0,999847695	foliation
50	72	36	0,314159265	-2,513274123	-0,181635632	-0,25	0,951056516	joint
50	84	209	0,104719755	0,506145483	0,050676405	0,091422654	0,994521895	joint
50	89	225	0,017453293	0,785398163	0,012340715	0,012340715	0,999847695	joint
50	47	274	0,750491578	1,640609497	0,680337046	-0,047573801	0,731353702	foliation
50	59	273	0,541052068	1,623156204	0,514332233	-0,02695501	0,857167301	foliation
50	57	293	0,575958653	1,972222055	0,501342875	-0,212807425	0,838670568	foliation
50	77	135	0,226892803	-0,785398163	-0,159064416	0,159064416	0,974370065	joint
50	67	328	0,401425728	2,583087293	0,207055952	-0,33135879	0,920504853	joint
50	71	25	0,331612558	-2,705260341	-0,137591048	-0,295064954	0,945518576	joint
50	40	256	0,872664626	1,326450232	0,743289649	0,185322924	0,64278761	joint
50	77	45	0,226892803	-2,35619449	-0,159064416	-0,159064416	0,974370065	joint
50	48	320	0,733038286	2,443460953	0,430108863	-0,512583783	0,743144825	joint
50	32	119	1,012290966	-1,064650844	-0,741719578	0,411141875	0,529919264	joint
50	32	312	1,012290966	2,303834613	0,630222554	-0,567454937	0,529919264	joint
50	81	230	0,157079633	0,872664626	0,119835753	0,100554136	0,987688341	joint
50	89	220	0,017453293	0,698131701	0,011218191	0,013369319	0,999847695	joint
50	40	260	0,872664626	1,396263402	0,754406507	0,133022222	0,64278761	joint
50	22	251	1,186823891	1,239183769	0,876669557	0,301861536	0,374606593	joint
50	61	280	0,506145483	1,745329252	0,477444273	-0,084186307	0,874619707	joint
50	58	285	0,558505361	1,832595715	0,511862703	-0,137153198	0,848048096	joint
50	85	246	0,087266463	1,151917306	0,079620733	0,035449434	0,996194698	joint
50	63	286	0,471238898	1,850049007	0,436403678	-0,125136741	0,891006524	foliation
50	49	286	0,715584993	1,850049007	0,630644415	-0,180834376	0,75470958	foliation
50	57	268	0,575958653	1,535889742	0,544307256	0,019007628	0,838670568	foliation
50	51	259	0,680678408	1,378810109	0,617758003	0,120079992	0,777145961	foliation
50	55	279	0,610865238	1,727875959	0,566514759	-0,089727123	0,819152044	foliation
50	43	283	0,820304748	1,79768913	0,712609154	-0,164518786	0,68199836	foliation
50	48	260	0,733038286	1,396263402	0,658965009	0,11619331	0,743144825	foliation
50	41	280	0,855211333	1,745329252	0,743243846	-0,131053943	0,656059029	foliation
50	26	116	1,117010721	-1,117010721	-0,807830738	0,394005377	0,438371147	joint
50	47	278	0,750491578	1,710422667	0,675361199	-0,094915827	0,731353702	foliation
50	43	278	0,820304748	1,710422667	0,724236218	-0,101784763	0,68199836	foliation
50	55	26	0,610865238	-2,687807048	-0,25143936	-0,515527086	0,819152044	joint
50	89	331	0,017453293	2,635447171	0,008461095	-0,015264219	0,999847695	joint
50	89	240	0,017453293	1,047197551	0,015114227	0,008726203	0,999847695	joint
50	24	244	1,151917306	1,117010721	0,821089218	0,40047197	0,406736643	joint
50	33	242	0,994837674	1,082104136	0,740502159	0,393731982	0,544639035	joint
50	27	135	1,099557429	-0,785398163	-0,630036755	0,630036755	0,4539905	joint
50	43	281	0,820304748	1,762782545	0,717916674	-0,139548865	0,68199836	joint
50	47	175	0,750491578	-0,087266463	-0,059440074	0,67940315	0,731353702	joint
50	49	251	0,715584993	1,239183769	0,620315999	0,213591927	0,75470958	foliation
50	40	256	0,872664626	1,326450232	0,743289649	0,185322924	0,64278761	foliation
50	61	280	0,506145483	1,745329252	0,477444273	-0,084186307	0,874619707	foliation
50	49	280	0,715584993	1,745329252	0,646092018	-0,113923455	0,75470958	joint
50	67	28	0,401425728	-2,652900463	-0,183437154	-0,344995109	0,920504853	joint

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
50	77	45	0,226892803	-2,35619449	-0,159064416	-0,159064416	0,974370065	joint
50	29	117	1,064650844	-1,099557429	-0,779291865	0,397069038	0,48480962	joint
50	31	123	1,029744259	-0,994837674	-0,718880987	0,466846772	0,515038075	joint
50	60	18	0,523598776	-2,827433388	-0,154508497	-0,475528258	0,866025404	joint
50	46	347	0,767944871	2,914699851	0,156264133	-0,676854321	0,7193398	joint
50	36	112	0,942477796	-1,186823891	-0,750107495	0,3030631	0,587785252	joint
50	72	152	0,314159265	-0,488692191	-0,145074691	0,272845811	0,951056516	joint
50	18	78	1,256637061	-1,780235837	-0,93027365	-0,197735768	0,309016994	joint
50	29	140	1,064650844	-0,698131701	-0,562194711	0,669997566	0,48480962	joint
50	35	79	0,959931089	-1,762782545	-0,804101914	-0,156301579	0,573576436	joint
50	74	284	0,27925268	1,815142422	0,267449748	-0,066682712	0,961261696	joint
50	87	230	0,052359878	0,872664626	0,040091668	0,033640904	0,998629535	joint
50	89	226	0,017453293	0,802851456	0,012554211	0,01212346	0,999847695	joint
50	57	276	0,575958653	1,675516082	0,541655445	-0,056930281	0,838670568	joint
50	88	180	0,034906585	0	0	0,034899497	0,999390827	joint
50	85	178	0,087266463	-0,034906585	-0,003041692	0,08710265	0,996194698	joint
50	81	318	0,157079633	2,408554368	0,104675088	-0,116253463	0,987688341	joint
50	44	286	0,802851456	1,850049007	0,691473796	-0,19827692	0,69465837	foliation
50	20	247	1,221730476	1,169370599	0,864991618	0,367167158	0,342020143	joint
50	74	148	0,27925268	-0,558505361	-0,146065545	0,233753735	0,961261696	joint
50	70	138	0,34906585	-0,733038286	-0,228856146	0,2541705	0,939692621	joint
50	69	235	0,366519143	0,959931089	0,293557838	0,205551411	0,933580426	joint
50	41	110	0,855211333	-1,221730476	-0,709195023	0,258125879	0,656059029	joint
50	87	27	0,052359878	-2,670353756	-0,023760027	-0,046631678	0,998629535	joint
50	85	339	0,087266463	2,775073511	0,031233825	-0,081366895	0,996194698	joint
50	28	131	1,082104136	-0,855211333	-0,666369007	0,57926574	0,469471563	joint
50	52	294	0,663225116	1,989675347	0,562434744	-0,250412082	0,788010754	joint
50	42	281	0,837758041	1,762782545	0,729491162	-0,141798718	0,669130606	foliation
50	64	345	0,453785606	2,879793266	0,113458802	-0,423434012	0,898794046	joint
50	61	274	0,506145483	1,640609497	0,483628648	-0,03381861	0,874619707	foliation
50	55	275	0,610865238	1,658062789	0,571393805	-0,04999048	0,819152044	foliation
50	63	295	0,471238898	2,00712864	0,411455125	-0,191864676	0,891006524	foliation
50	65	275	0,436332313	1,658062789	0,421010072	-0,036833609	0,906307787	foliation
50	57	288	0,575958653	1,884955592	0,517982503	-0,168302718	0,838670568	foliation
50	65	215	0,436332313	0,610865238	0,242403877	0,346188613	0,906307787	joint
50	78	296	0,20943951	2,024581932	0,18686979	-0,091142486	0,978147601	joint
50	54	32	0,628318531	-2,583087293	-0,311478728	-0,498470164	0,809016994	joint
50	83	254	0,122173048	1,291543646	0,117148332	0,033591744	0,992546152	joint
50	89	208	0,017453293	0,488692191	0,008193409	0,01540956	0,999847695	joint
50	88	211	0,034906585	0,541052068	0,01797457	0,029914707	0,999390827	joint
50	77	205	0,226892803	0,436332313	0,095068424	0,203874892	0,974370065	joint
50	64	22	0,453785606	-2,757620218	-0,164216722	-0,40645065	0,898794046	joint
50	84	240	0,104719755	1,047197551	0,090524305	0,052264232	0,994521895	joint
50	85	153	0,087266463	-0,471238898	-0,039567879	0,077656335	0,996194698	joint
50	29	140	1,064650844	-0,698131701	-0,562194711	0,669997566	0,48480962	joint
50	81	185	0,157079633	0,087266463	0,013634162	0,155839185	0,987688341	joint
50	62	291	0,488692191	1,93731547	0,438289462	-0,168243561	0,882947593	joint
50	59	278	0,541052068	1,710422667	0,51002576	-0,071679446	0,857167301	joint
50	56	284	0,593411946	1,815142422	0,542582484	-0,135281007	0,829037573	joint
50	63	286	0,471238898	1,850049007	0,436403678	-0,125136741	0,891006524	joint
50	58	292	0,558505361	1,954768762	0,491332586	-0,19851125	0,848048096	joint
50	42	270	0,837758041	1,570796327	0,743144825	4,55231E-17	0,669130606	foliation
50	43	277	0,820304748	1,692969374	0,725902302	-0,089129595	0,68199836	foliation
50	72	119	0,314159265	-1,064650844	-0,270272353	0,149814412	0,951056516	joint
50	81	265	0,157079633	1,483529864	0,155839185	0,013634162	0,987688341	joint
50	78	261	0,20943951	1,413716694	0,205351953	0,032524554	0,978147601	joint
50	41	275	0,855211333	1,658062789	0,751837682	-0,065777274	0,656059029	foliation

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
50	69	266	0,366519143	1,500983157	0,357494983	0,024998484	0,933580426	joint
50	78	217	0,20943951	0,645771823	0,125124379	0,166045659	0,978147601	joint
50	36	275	0,942477796	1,658062789	0,80593844	-0,070510477	0,587785252	joint
50	41	263	0,855211333	1,448623279	0,749084089	0,091975961	0,656059029	joint
50	54	268	0,628318531	1,535889742	0,587427189	0,020513409	0,809016994	joint
51 - 60	46	279	0,767944871	1,727875959	0,686105973	-0,108668511	0,7193398	foliation
60	88	208	0,034906585	0,488692191	0,016384321	0,030814427	0,999390827	joint
60	57	274	0,575958653	1,640609497	0,543312322	-0,037992099	0,838670568	foliation
60	57	288	0,575958653	1,884955592	0,517982503	-0,168302718	0,838670568	foliation
60	57	277	0,575958653	1,692969374	0,540579378	-0,066374802	0,838670568	foliation
60	59	268	0,541052068	1,535889742	0,514724328	0,01797457	0,857167301	foliation
60	53	270	0,645771823	1,570796327	0,601815023	3,68656E-17	0,79863551	foliation
60	79	215	0,191986218	0,610865238	0,109443544	0,156301579	0,981627183	joint
60	28	119	1,082104136	-1,064650844	-0,772243365	0,428061487	0,469471563	joint
60	21	115	1,204277184	-1,134464014	-0,84611121	0,394548137	0,35836795	joint
60	32	21	1,012290966	-2,775073511	-0,303913257	-0,791721103	0,529919264	joint
60	29	120	1,064650844	-1,047197551	-0,757442885	0,437309854	0,48480962	joint
60	76	42	0,244346095	-2,408554368	-0,161877345	-0,179783005	0,970295726	joint
60	24	247	1,151917306	1,169370599	0,840923028	0,356950648	0,406736643	joint
60	63	54	0,471238898	-2,199114858	-0,36728603	-0,26684892	0,891006524	joint
60	71	53	0,331612558	-2,21656815	-0,260010289	-0,195931806	0,945518576	joint
60	66	63	0,41887902	-2,042035225	-0,362405003	-0,184654572	0,913545458	joint
60	87	230	0,052359878	0,872664626	0,040091668	0,033640904	0,998629535	joint
60	68	48	0,383972435	-2,303834613	-0,278386951	-0,250660737	0,927183855	joint
60	92	276	-0,034906585	1,675516082	-0,034708314	0,003647991	0,999390827	joint
60	87	229	0,052359878	0,855211333	0,039498448	0,034335477	0,998629535	joint
60	78	213	0,20943951	0,575958653	0,113236823	0,174369416	0,978147601	joint
60	44	280	0,802851456	1,745329252	0,708411412	-0,124912045	0,69465837	foliation
60	42	273	0,837758041	1,623156204	0,742126371	-0,038893195	0,669130606	foliation
60	47	264	0,750491578	1,466076572	0,678262302	0,071288241	0,731353702	foliation
60	44	263	0,802851456	1,448623279	0,713977951	0,087665469	0,69465837	foliation
60	38	289	0,907571211	1,902408885	0,745078805	-0,256551207	0,615661475	foliation
60	47	263	0,750491578	1,448623279	0,676914848	0,083114692	0,731353702	foliation
60	63	267	0,471238898	1,518436449	0,453368322	0,023760027	0,891006524	joint
60	45	263	0,785398163	1,448623279	0,701836114	0,086174639	0,707106781	joint
60	27	268	1,099557429	1,535889742	0,890463747	0,031095679	0,4539905	joint
60	40	282	0,872664626	1,780235837	0,749304534	-0,159269595	0,64278761	joint
60	43	287	0,820304748	1,8675023	0,699397023	-0,213827128	0,68199836	foliation
60	43	281	0,820304748	1,762782545	0,717916674	-0,139548865	0,68199836	foliation
60	84	238	0,104719755	1,012290966	0,088645164	0,055391646	0,994521895	joint
60	68	22	0,383972435	-2,757620218	-0,1403301	-0,347329185	0,927183855	joint
60	85	347	0,087266463	2,914699851	0,019605776	-0,084921947	0,996194698	joint
60	45	268	0,785398163	1,535889742	0,706676031	0,024677671	0,707106781	joint
60	60	286	0,523598776	1,850049007	0,480630848	-0,137818678	0,866025404	foliation
60	58	284	0,558505361	1,815142422	0,514178397	-0,128199073	0,848048096	foliation
60	53	286	0,645771823	1,850049007	0,57850173	-0,165882702	0,79863551	foliation
60	54	277	0,628318531	1,692969374	0,58340399	-0,071633003	0,809016994	foliation
60	74	260	0,27925268	1,396263402	0,271449805	0,047863925	0,961261696	foliation
60	84	272	0,104719755	1,605702912	0,104464787	-0,003647991	0,994521895	foliation
60	59	268	0,541052068	1,535889742	0,514724328	0,01797457	0,857167301	foliation
60	80	277	0,174532925	1,692969374	0,17235383	-0,021162389	0,984807753	joint
60	88	280	0,034906585	1,745329252	0,034369295	-0,006060234	0,999390827	joint
60	65	44	0,436332313	-2,373647783	-0,293575313	-0,304006136	0,906307787	joint
60	30	115	1,047197551	-1,134464014	-0,784885567	0,365998151	0,5	joint
60	83	204	0,122173048	0,41887902	0,049568728	0,111333185	0,992546152	joint
60	27	247	1,099557429	1,169370599	0,82017583	0,348143985	0,4539905	joint
60	43	265	0,820304748	1,483529864	0,72857068	0,063741675	0,68199836	foliation

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
60	40	271	0,872664626	1,588249619	0,765927771	-0,013369319	0,64278761	foliation
60	86	356	0,06981317	3,071779484	0,004865966	-0,06958655	0,99756405	joint
60	71	143	0,331612558	-0,645771823	-0,195931806	0,260010289	0,945518576	joint
60	41	285	0,855211333	1,832595715	0,728993475	-0,195333213	0,656059029	foliation
60	46	180	0,767944871	0	0	0,69465837	0,7193398	joint
60	51	266	0,680678408	1,500983157	0,627787398	0,043899171	0,777145961	joint
60	71	10	0,331612558	-2,967059728	-0,056534317	-0,320622043	0,945518576	joint
60	40	279	0,872664626	1,727875959	0,756613165	-0,119835753	0,64278761	joint
60	42	271	0,837758041	1,588249619	0,743031641	-0,012969666	0,669130606	joint
60	43	283	0,820304748	1,79768913	0,712609154	-0,164518786	0,68199836	joint
60	63	272	0,471238898	1,605702912	0,453713941	-0,01584404	0,891006524	foliation
60	57	275	0,575958653	1,658062789	0,542566519	-0,04746842	0,838670568	foliation
60	54	276	0,628318531	1,675516082	0,584565303	-0,061440289	0,809016994	foliation
60	55	275	0,610865238	1,658062789	0,571393805	-0,04999048	0,819152044	foliation
60	58	284	0,558505361	1,815142422	0,514178397	-0,128199073	0,848048096	foliation
60	84	143	0,104719755	-0,645771823	-0,0629068	0,083480143	0,994521895	joint
60	63	218	0,471238898	0,663225116	0,279504461	0,357749396	0,891006524	joint
60	51	277	0,680678408	1,692969374	0,624629532	-0,076694863	0,777145961	joint
60	85	227	0,087266463	0,820304748	0,063741675	0,059440074	0,996194698	joint
60	60	275	0,523598776	1,658062789	0,498097349	-0,043577871	0,866025404	joint
60	41	253	0,855211333	1,274090354	0,721732361	0,220655727	0,656059029	joint
60	50	268	0,698131701	1,535889742	0,642396041	0,022432964	0,766044443	foliation
60	76	37	0,244346095	-2,49582083	-0,145592231	-0,193207416	0,970295726	joint
60	52	131	0,663225116	-0,855211333	-0,464645614	0,40391027	0,788010754	joint
60	66	225	0,41887902	0,785398163	0,287606238	0,287606238	0,913545458	joint
60	47	283	0,750491578	1,79768913	0,664518786	-0,15341625	0,731353702	joint
60	70	210	0,34906585	0,523598776	0,171010072	0,296198133	0,939692621	joint
60	88	168	0,034906585	-0,20943951	-0,007256013	0,034136859	0,999390827	joint
60	70	210	0,34906585	0,523598776	0,171010072	0,296198133	0,939692621	joint
60	45	185	0,785398163	0,087266463	0,061628417	0,704416026	0,707106781	joint
60	37	268	0,925024504	1,535889742	0,798149003	0,027871977	0,601815023	joint
60	88	224	0,034906585	0,767944871	0,024243228	0,025104597	0,999390827	joint
60	68	211	0,383972435	0,541052068	0,192936659	0,321100523	0,927183855	joint
60	25	119	1,134464014	-1,064650844	-0,792674651	0,439386734	0,422618262	joint
60	80	237	0,174532925	0,994837674	0,145633616	0,094575576	0,984807753	joint
60	88	152	0,034906585	-0,488692191	-0,016384321	0,030814427	0,999390827	joint
60	26	119	1,117010721	-1,064650844	-0,786102986	0,435744	0,438371147	joint
60	54	276	0,628318531	1,675516082	0,584565303	-0,061440289	0,809016994	foliation
60	65	270	0,436332313	1,570796327	0,422618262	2,58885E-17	0,906307787	foliation
60	38	272	0,907571211	1,605702912	0,787530719	-0,027501179	0,615661475	joint
60	87	141	0,052359878	-0,680678408	-0,032936084	0,040672677	0,998629535	joint
60	86	173	0,06981317	-0,122173048	-0,008501176	0,06923652	0,99756405	joint
surface	44	282	0,802851456	1,780235837	0,7036205	-0,149559154	0,69465837	foliation
surface	49	284	0,715584993	1,815142422	0,636571272	-0,158715044	0,75470958	foliation
surface	51	278	0,680678408	1,710422667	0,623195888	-0,08758447	0,777145961	foliation
surface	44	287	0,802851456	1,8675023	0,687908072	-0,210314604	0,69465837	foliation
surface	55	283	0,610865238	1,79768913	0,558875709	-0,129026624	0,819152044	foliation
surface	57	284	0,575958653	1,815142422	0,528460928	-0,131760108	0,838670568	foliation
surface	63	282	0,471238898	1,780235837	0,444069718	-0,094389932	0,891006524	foliation
surface	57	274	0,575958653	1,640609497	0,543312322	-0,037992099	0,838670568	foliation
surface	47	271	0,750491578	1,588249619	0,681894488	-0,011902513	0,731353702	foliation
surface	47	275	0,750491578	1,658062789	0,67940315	-0,059440074	0,731353702	foliation
surface	43	285	0,820304748	1,832595715	0,706433429	-0,189288267	0,68199836	foliation
surface	47	283	0,750491578	1,79768913	0,664518786	-0,15341625	0,731353702	foliation
surface	57	282	0,575958653	1,780235837	0,532737365	-0,113236823	0,838670568	foliation
surface	43	279	0,820304748	1,727875959	0,722349524	-0,114408925	0,68199836	foliation
surface	53	268	0,645771823	1,535889742	0,601448414	0,021003041	0,79863551	foliation

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
surface	48	277	0,733038286	1,692969374	0,664143008	-0,081546508	0,743144825	foliation
surface	52	274	0,663225116	1,640609497	0,614161755	-0,042946374	0,788010754	foliation
surface	55	273	0,610865238	1,623156204	0,57279037	-0,030018671	0,819152044	foliation
surface	61	272	0,506145483	1,605702912	0,484514287	-0,016919612	0,874619707	foliation
surface	44	278	0,802851456	1,710422667	0,712339235	-0,100112751	0,69465837	foliation
surface	59	277	0,541052068	1,692969374	0,511199059	-0,062767352	0,857167301	foliation
surface	56	277	0,593411946	1,692969374	0,555024764	-0,068148472	0,829037573	foliation
surface	44	288	0,802851456	1,884955592	0,684132805	-0,222288223	0,69465837	foliation
surface	48	284	0,733038286	1,815142422	0,649254568	-0,161877345	0,743144825	foliation
surface	56	278	0,593411946	1,710422667	0,553750877	-0,07782461	0,829037573	foliation
surface	47	274	0,750491578	1,640609497	0,680337046	-0,047573801	0,731353702	foliation
surface	42	272	0,837758041	1,605702912	0,742692122	-0,02593538	0,669130606	foliation
surface	44	278	0,802851456	1,710422667	0,712339235	-0,100112751	0,69465837	foliation
surface	46	278	0,767944871	1,710422667	0,687898003	-0,09667776	0,7193398	foliation
surface	62	284	0,488692191	1,815142422	0,455526251	-0,11357545	0,882947593	foliation
surface	54	284	0,628318531	1,815142422	0,570325518	-0,142198122	0,809016994	foliation
surface	43	273	0,820304748	1,623156204	0,730351407	-0,038276095	0,68199836	foliation
surface	53	278	0,645771823	1,710422667	0,595958201	-0,083756463	0,79863551	foliation
surface	36	284	0,942477796	1,815142422	0,784985732	-0,195718925	0,587785252	foliation
surface	34	283	0,977384381	1,79768913	0,807789393	-0,186492876	0,559192903	foliation
surface	43	277	0,820304748	1,692969374	0,725902302	-0,089129595	0,68199836	foliation
surface	49	282	0,715584993	1,780235837	0,641722565	-0,136402342	0,75470958	foliation
surface	47	265	0,750491578	1,483529864	0,67940315	0,059440074	0,731353702	foliation
surface	40	266	0,872664626	1,500983157	0,764178397	0,053436559	0,64278761	foliation
surface	63	269	0,471238898	1,553343034	0,453921355	0,007923227	0,891006524	foliation
surface	43	276	0,820304748	1,675516082	0,72734727	-0,076447279	0,68199836	foliation
surface	42	275	0,837758041	1,658062789	0,740316935	-0,064769339	0,669130606	foliation
surface	59	287	0,541052068	1,8675023	0,492533361	-0,15058256	0,857167301	foliation
surface	40	267	0,872664626	1,518436449	0,764994606	0,040091668	0,64278761	foliation
surface	57	280	0,575958653	1,745329252	0,536364744	-0,094575576	0,838670568	foliation
surface	40	279	0,872664626	1,727875959	0,756613165	-0,119835753	0,64278761	foliation
surface	38	273	0,907571211	1,623156204	0,786930812	-0,041241296	0,615661475	foliation
surface	72	283	0,314159265	1,79768913	0,301096909	-0,069513699	0,951056516	foliation
surface	50	272	0,698131701	1,605702912	0,642396041	-0,022432964	0,766044443	foliation
surface	51	273	0,680678408	1,623156204	0,628457929	-0,032936084	0,777145961	foliation
surface	75	263	0,261799388	1,448623279	0,256889847	0,031542107	0,965925826	foliation
surface	45	280	0,785398163	1,745329252	0,69636424	-0,122787804	0,707106781	foliation
surface	41	291	0,855211333	1,93731547	0,704582092	-0,270463725	0,656059029	foliation
surface	42	290	0,837758041	1,919862177	0,698327709	-0,2541705	0,669130606	foliation
surface	45	280	0,785398163	1,745329252	0,69636424	-0,122787804	0,707106781	foliation
surface	40	282	0,872664626	1,780235837	0,749304534	-0,159269595	0,64278761	foliation
surface	40	280	0,872664626	1,745329252	0,754406507	-0,133022222	0,64278761	foliation
surface	50	288	0,698131701	1,884955592	0,611327345	-0,198632295	0,766044443	foliation
surface	52	285	0,663225116	1,832595715	0,594683319	-0,159344915	0,788010754	foliation
surface	58	277	0,558505361	1,692969374	0,525969326	-0,064580913	0,848048096	foliation
surface	52	270	0,663225116	1,570796327	0,615661475	3,77138E-17	0,788010754	foliation
surface	52	274	0,663225116	1,640609497	0,614161755	-0,042946374	0,788010754	foliation
surface	49	270	0,715584993	1,570796327	0,656059029	4,01885E-17	0,75470958	foliation
surface	46	281	0,767944871	1,762782545	0,68189554	-0,132547066	0,7193398	foliation
surface	48	274	0,733038286	1,640609497	0,667500638	-0,046676192	0,743144825	foliation
surface	44	272	0,802851456	1,605702912	0,718901598	-0,025104597	0,69465837	foliation
surface	55	282	0,610865238	1,780235837	0,561042415	-0,119253247	0,819152044	foliation
surface	56	284	0,593411946	1,815142422	0,542582484	-0,135281007	0,829037573	foliation
surface	48	276	0,733038286	1,675516082	0,665465039	-0,069943194	0,743144825	foliation
surface	53	270	0,645771823	1,570796327	0,601815023	3,68656E-17	0,79863551	foliation
surface	58	281	0,558505361	1,762782545	0,520183155	-0,101113362	0,848048096	foliation
surface	54	278	0,628318531	1,710422667	0,582064967	-0,081803896	0,809016994	foliation

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
surface	53	287	0,645771823	1,8675023	0,575518569	-0,175953684	0,79863551	foliation
surface	36	273	0,942477796	1,623156204	0,807908265	-0,042340678	0,587785252	foliation
surface	41	279	0,855211333	1,727875959	0,745417853	-0,118062589	0,656059029	foliation
surface	57	269	0,575958653	1,553343034	0,544556084	0,009505262	0,838670568	foliation
surface	37	275	0,925024504	1,658062789	0,795596461	-0,069605671	0,601815023	foliation
surface	55	272	0,610865238	1,605702912	0,573227029	-0,020017529	0,819152044	foliation
surface	39	280	0,890117919	1,745329252	0,765339368	-0,13494998	0,629320391	foliation
surface	31	266	1,029744259	1,500983157	0,855079284	0,059792968	0,515038075	foliation
surface	43	276	0,820304748	1,675516082	0,72734727	-0,076447279	0,68199836	foliation
surface	38	275	0,907571211	1,658062789	0,785012135	-0,068679663	0,615661475	foliation
surface	53	254	0,645771823	1,291543646	0,57850173	0,165882702	0,79863551	foliation
surface	31	277	1,029744259	1,692969374	0,850778106	-0,104462416	0,515038075	foliation
surface	43	267	0,820304748	1,518436449	0,730351407	0,038276095	0,68199836	foliation
surface	40	268	0,872664626	1,535889742	0,76557779	0,026734566	0,64278761	foliation
surface	59	271	0,541052068	1,588249619	0,514959632	-0,008988654	0,857167301	foliation
surface	89	276	0,017453293	1,675516082	0,0173568	-0,001824273	0,999847695	foliation
surface	49	262	0,715584993	1,431169987	0,649674308	0,091305769	0,75470958	foliation
surface	53	266	0,645771823	1,500983157	0,600349032	0,041980494	0,79863551	foliation
surface	86	249	0,06981317	1,204277184	0,065123279	0,024998484	0,99756405	foliation
surface	57	270	0,575958653	1,570796327	0,544639035	3,33632E-17	0,838670568	foliation
surface	50	277	0,698131701	1,692969374	0,637996368	-0,078336104	0,766044443	foliation
surface	34	95	0,977384381	-1,483529864	-0,825882834	0,072255385	0,559192903	foliation
surface	25	120	1,134464014	-1,047197551	-0,784885567	0,453153894	0,422618262	foliation
surface	60	120	0,523598776	-1,047197551	-0,433012702	0,25	0,866025404	foliation
surface	15	130	1,308996939	-0,872664626	-0,739942112	0,620885153	0,258819045	foliation
surface	42	145	0,837758041	-0,610865238	-0,426250361	0,608748603	0,669130606	foliation
surface	10	190	1,396263402	0,174532925	0,171010072	0,96984631	0,173648178	foliation
surface	20	195	1,221730476	0,261799388	0,243210347	0,907673371	0,342020143	foliation
surface	5	225	1,483529864	0,785398163	0,704416026	0,704416026	0,087155743	foliation
surface	35	229	0,959931089	0,855211333	0,618221895	0,537412095	0,573576436	foliation
surface	40	230	0,872664626	0,872664626	0,586824089	0,492403877	0,64278761	foliation
surface	55	233	0,610865238	0,925024504	0,45807851	0,345186916	0,819152044	foliation
surface	30	235	1,047197551	0,959931089	0,70940648	0,496731765	0,5	foliation
surface	31	235	1,029744259	0,959931089	0,702150347	0,491650966	0,515038075	foliation
surface	42	235	0,837758041	0,959931089	0,608748603	0,426250361	0,669130606	foliation
surface	60	235	0,523598776	0,959931089	0,409576022	0,286788218	0,866025404	foliation
surface	30	240	1,047197551	1,047197551	0,75	0,433012702	0,5	foliation
surface	27	241	1,099557429	1,064650844	0,779291865	0,431968535	0,4539905	foliation
surface	21	244	1,204277184	1,117010721	0,839096529	0,409254722	0,35836795	foliation
surface	30	245	1,047197551	1,134464014	0,784885567	0,365998151	0,5	foliation
surface	45	245	0,785398163	1,134464014	0,640856382	0,298836239	0,707106781	foliation
surface	22	245	1,186823891	1,134464014	0,840313947	0,391844829	0,374606593	foliation
surface	35	245	0,959931089	1,134464014	0,742403877	0,346188613	0,573576436	foliation
surface	50	249	0,698131701	1,204277184	0,600093931	0,230354478	0,766044443	foliation
surface	29	250	1,064650844	1,221730476	0,821873685	0,299137558	0,48480962	foliation
surface	58	250	0,558505361	1,221730476	0,497961222	0,181243063	0,848048096	foliation
surface	60	250	0,523598776	1,221730476	0,46984631	0,171010072	0,866025404	foliation
surface	35	253	0,959931089	1,274090354	0,783358996	0,23949688	0,573576436	foliation
surface	30	255	1,047197551	1,308996939	0,836516304	0,224143868	0,5	foliation
surface	40	255	0,872664626	1,308996939	0,739942112	0,198266891	0,64278761	foliation
surface	35	255	0,959931089	1,308996939	0,791240115	0,21201215	0,573576436	foliation
surface	78	255	0,20943951	1,308996939	0,200827272	0,053811505	0,978147601	foliation
surface	40	255	0,872664626	1,308996939	0,739942112	0,198266891	0,64278761	foliation
surface	50	260	0,698131701	1,396263402	0,633022222	0,111618897	0,766044443	foliation
surface	40	260	0,872664626	1,396263402	0,754406507	0,133022222	0,64278761	foliation
surface	40	260	0,872664626	1,396263402	0,754406507	0,133022222	0,64278761	foliation
surface	50	260	0,698131701	1,396263402	0,633022222	0,111618897	0,766044443	foliation

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
surface	35	260	0,959931089	1,396263402	0,806707284	0,14224426	0,573576436	foliation
surface	7	262	1,448623279	1,431169987	0,982886761	0,138135726	0,121869343	foliation
surface	45	265	0,785398163	1,483529864	0,704416026	0,061628417	0,707106781	foliation
surface	50	265	0,698131701	1,483529864	0,640341609	0,056022632	0,766044443	foliation
surface	39	267	0,890117919	1,518436449	0,77608091	0,040672677	0,629320391	foliation
surface	55	270	0,610865238	1,570796327	0,573576436	3,51358E-17	0,819152044	foliation
surface	51	270	0,680678408	1,570796327	0,629320391	3,85505E-17	0,777145961	foliation
surface	42	274	0,837758041	1,640609497	0,741334562	-0,051839163	0,669130606	foliation
surface	45	275	0,785398163	1,658062789	0,704416026	-0,061628417	0,707106781	foliation
surface	52	275	0,663225116	1,658062789	0,613318698	-0,053658433	0,788010754	foliation
surface	25	275	1,134464014	1,658062789	0,902859012	-0,078989928	0,422618262	foliation
surface	62	280	0,488692191	1,745329252	0,462339235	-0,081522881	0,882947593	foliation
surface	13	285	1,343903524	1,832595715	0,94116921	-0,25218553	0,224951054	foliation
surface	35	285	0,959931089	1,832595715	0,791240115	-0,21201215	0,573576436	foliation
surface	15	290	1,308996939	1,919862177	0,907673371	-0,33036609	0,258819045	foliation
surface	38	294	0,907571211	1,989675347	0,719883645	-0,320512849	0,615661475	foliation
surface	39	297	0,890117919	2,042035225	0,692442122	-0,352816883	0,629320391	foliation
surface	30	300	1,047197551	2,094395102	0,75	-0,433012702	0,5	foliation
surface	47	300	0,750491578	2,094395102	0,590627905	-0,34099918	0,731353702	foliation
surface	25	300	1,134464014	2,094395102	0,784885567	-0,453153894	0,422618262	foliation
surface	20	310	1,221730476	2,268928028	0,71984631	-0,604022774	0,342020143	foliation
surface	41	310	0,855211333	2,268928028	0,57814108	-0,485117967	0,656059029	foliation
surface	24	320	1,151917306	2,443460953	0,587215701	-0,699816421	0,406736643	foliation
surface	4	322	1,500983157	2,478367538	0,614161755	-0,786091199	0,069756474	foliation
surface	10	330	1,396263402	2,617993878	0,492403877	-0,852868532	0,173648178	foliation
surface	40	330	0,872664626	2,617993878	0,383022222	-0,663413948	0,64278761	foliation
surface	23	330	1,169370599	2,617993878	0,460252427	-0,797180587	0,390731128	foliation
surface	24	340	1,151917306	2,792526803	0,312450948	-0,858451925	0,406736643	foliation
surface	48	350	0,733038286	2,967059728	0,11619331	-0,658965009	0,743144825	foliation
surface	8	355	1,431169987	3,054326191	0,086307549	-0,9864998	0,139173101	foliation
surface	42	55	0,837758041	-2,181661565	-0,608748603	-0,426250361	0,669130606	foliation
surface	42	69	0,837758041	-1,93731547	-0,693785463	-0,266319287	0,669130606	foliation
surface	35	79	0,959931089	-1,762782545	-0,804101914	-0,156301579	0,573576436	foliation
surface	50	85	0,698131701	-1,658062789	-0,640341609	-0,056022632	0,766044443	foliation
surface	54	239	0,628318531	1,029744259	0,503830298	0,302731785	0,809016994	joint
surface	59	270	0,541052068	1,570796327	0,515038075	3,15499E-17	0,857167301	joint
surface	88	216	0,034906585	0,628318531	0,020513409	0,028234286	0,999390827	joint
surface	45	295	0,785398163	2,00712864	0,640856382	-0,298836239	0,707106781	joint
surface	59	238	0,541052068	1,012290966	0,436777059	0,272928598	0,857167301	joint
surface	17	266	1,274090354	1,500983157	0,953975246	0,066708448	0,292371705	joint
surface	46	274	0,767944871	1,640609497	0,692966218	-0,048456918	0,7193398	joint
surface	48	288	0,733038286	1,884955592	0,636381023	-0,206772729	0,743144825	joint
surface	47	220	0,750491578	0,698131701	0,438380096	0,522441054	0,731353702	joint
surface	58	83	0,558505361	-1,692969374	-0,525969326	-0,064580913	0,848048096	joint
surface	89	218	0,017453293	0,663225116	0,010744774	0,013752684	0,999847695	joint
surface	83	38	0,122173048	-2,478367538	-0,07503026	-0,096034353	0,992546152	joint
surface	57	249	0,575958653	1,204277184	0,508464343	0,195181174	0,838670568	joint
surface	59	239	0,541052068	1,029744259	0,441473796	0,265264219	0,857167301	joint
surface	72	222	0,314159265	0,733038286	0,206772729	0,22964438	0,951056516	joint
surface	68	75	0,383972435	-1,832595715	-0,361842183	-0,096955321	0,927183855	joint
surface	87	53	0,052359878	-2,21656815	-0,041797353	-0,031496565	0,998629535	joint
surface	68	221	0,383972435	0,715584993	0,245764038	0,282719185	0,927183855	joint
surface	66	221	0,41887902	0,715584993	0,266843247	0,306968041	0,913545458	joint
surface	73	228	0,296705973	0,837758041	0,217274519	0,195634856	0,956304756	joint
surface	49	205	0,715584993	0,436332313	0,277262526	0,594591407	0,75470958	joint
surface	88	47	0,034906585	-2,321287905	-0,025523876	-0,0238014	0,999390827	joint
surface	68	90	0,383972435	-1,570796327	-0,374606593	2,29474E-17	0,927183855	joint

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
surface	62	245	0,488692191	1,134464014	0,425485733	0,198407256	0,882947593	joint
surface	62	242	0,488692191	1,082104136	0,414518786	0,220403548	0,882947593	joint
surface	48	298	0,733038286	2,059488517	0,590807258	-0,314137791	0,743144825	joint
surface	47	291	0,750491578	1,93731547	0,63670032	-0,244406354	0,731353702	joint
surface	56	241	0,593411946	1,064650844	0,489081133	0,271102099	0,829037573	joint
surface	89	216	0,017453293	0,628318531	0,010258267	0,014119293	0,999847695	joint
surface	68	232	0,383972435	0,907571211	0,295194024	0,230630848	0,927183855	joint
surface	61	228	0,506145483	0,837758041	0,360283761	0,324400955	0,874619707	joint
surface	55	280	0,610865238	1,745329252	0,564862521	-0,099600503	0,819152044	joint
surface	88	167	0,034906585	-0,226892803	-0,007850679	0,034005025	0,999390827	joint
surface	58	8	0,558505361	-3,001966313	-0,073750507	-0,524762126	0,848048096	joint
surface	50	266	0,698131701	1,500983157	0,641221811	0,044838597	0,766044443	joint
surface	83	227	0,122173048	0,820304748	0,089129595	0,083114692	0,992546152	joint
surface	87	231	0,052359878	0,890117919	0,040672677	0,032936084	0,998629535	joint
surface	86	235	0,06981317	0,959931089	0,057141158	0,04001067	0,99756405	joint
surface	88	224	0,034906585	0,767944871	0,024243228	0,025104597	0,999390827	joint
surface	61	50	0,506145483	-2,268928028	-0,371385716	-0,311629617	0,874619707	joint
surface	39	112	0,890117919	-1,186823891	-0,720557188	0,291124001	0,629320391	joint
surface	56	286	0,593411946	1,850049007	0,537530719	-0,154134453	0,829037573	joint
surface	55	276	0,610865238	1,675516082	0,570434325	-0,059955063	0,819152044	joint
surface	86	11	0,06981317	-2,949606436	-0,013310163	-0,068474851	0,99756405	joint
surface	53	72	0,645771823	-1,884955592	-0,572360099	-0,18597107	0,79863551	joint
surface	88	232	0,034906585	0,907571211	0,027501179	0,021486276	0,999390827	joint
surface	89	237	0,017453293	0,994837674	0,01463682	0,009505262	0,999847695	joint
surface	62	218	0,488692191	0,663225116	0,289035555	0,36994864	0,882947593	joint
surface	89	76	0,017453293	-1,815142422	-0,016933995	-0,004222119	0,999847695	joint
surface	84	60	0,104719755	-2,094395102	-0,090524305	-0,052264232	0,994521895	joint
surface	86	37	0,06981317	-2,49582083	-0,041980494	-0,055709997	0,99756405	joint
surface	87	230	0,052359878	0,872664626	0,040091668	0,033640904	0,998629535	joint
surface	74	278	0,27925268	1,710422667	0,272954872	-0,038361306	0,961261696	joint
surface	54	284	0,628318531	1,815142422	0,570325518	-0,142198122	0,809016994	joint
surface	88	47	0,034906585	-2,321287905	-0,025523876	-0,0238014	0,999390827	joint
surface	61	285	0,506145483	1,832595715	0,468290133	-0,125477963	0,874619707	joint
surface	87	222	0,052359878	0,733038286	0,03501959	0,038893195	0,998629535	joint
surface	56	271	0,593411946	1,588249619	0,559107736	-0,009759262	0,829037573	joint
surface	89	210	0,017453293	0,523598776	0,008726203	0,015114227	0,999847695	joint
surface	89	241	0,017453293	1,064650844	0,015264219	0,008461095	0,999847695	joint
surface	78	195	0,20943951	0,261799388	0,053811505	0,200827272	0,978147601	joint
surface	89	230	0,017453293	0,872664626	0,013369319	0,011218191	0,999847695	joint
surface	84	240	0,104719755	1,047197551	0,090524305	0,052264232	0,994521895	joint
surface	57	273	0,575958653	1,623156204	0,543892626	-0,028504205	0,838670568	joint
surface	50	270	0,698131701	1,570796327	0,64278761	3,93755E-17	0,766044443	joint
surface	73	61	0,296705973	-2,07694181	-0,255714055	-0,141744615	0,956304756	joint
surface	62	279	0,488692191	1,727875959	0,463691589	-0,073441533	0,882947593	joint
surface	80	33	0,174532925	-2,565634	-0,094575576	-0,145633616	0,984807753	joint
surface	67	75	0,401425728	-1,832595715	-0,377417288	-0,101128658	0,920504853	joint
surface	71	310	0,331612558	2,268928028	0,249399676	-0,209271176	0,945518576	joint
surface	59	68	0,541052068	-1,954768762	-0,477534988	-0,192936659	0,857167301	joint
surface	33	298	0,994837674	2,059488517	0,740502159	-0,393731982	0,544639035	joint
surface	60	103	0,523598776	-1,343903524	-0,487185032	0,112475527	0,866025404	joint
surface	65	221	0,436332313	0,715584993	0,277262526	0,318954051	0,906307787	joint
surface	58	98	0,558505361	-1,431169987	-0,524762126	0,073750507	0,848048096	joint
surface	41	284	0,855211333	1,815142422	0,73229148	-0,182580772	0,656059029	joint
surface	70	36	0,34906585	-2,513274123	-0,201034396	-0,276700108	0,939692621	joint
surface	80	38	0,174532925	-2,478367538	-0,106908493	-0,136836631	0,984807753	joint
surface	86	233	0,06981317	0,925024504	0,055709997	0,041980494	0,99756405	joint
surface	62	186	0,488692191	0,104719755	0,049073141	0,466899748	0,882947593	joint

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
surface	89	190	0,017453293	0,174532925	0,003030579	0,017187265	0,999847695	joint
surface	89	35	0,017453293	-2,530727415	-0,010010289	-0,014296174	0,999847695	joint
surface	52	243	0,663225116	1,099557429	0,548558391	0,279504461	0,788010754	joint
surface	45	255	0,785398163	1,308996939	0,683012702	0,183012702	0,707106781	joint
surface	78	60	0,20943951	-2,094395102	-0,180056806	-0,103955845	0,978147601	joint
surface	89	33	0,017453293	-2,565634	-0,009505262	-0,01463682	0,999847695	joint
surface	68	58	0,383972435	-2,129301687	-0,317684408	-0,19851125	0,927183855	joint
surface	68	58	0,383972435	-2,129301687	-0,317684408	-0,19851125	0,927183855	joint
surface	73	63	0,296705973	-2,042035225	-0,260505096	-0,132733976	0,956304756	joint
surface	72	59	0,314159265	-2,111848395	-0,264879263	-0,159155518	0,951056516	joint
surface	70	344	0,34906585	2,862339973	0,094273528	-0,328770863	0,939692621	joint
surface	77	53	0,226892803	-2,21656815	-0,1796539	-0,135378924	0,974370065	joint
surface	59	271	0,541052068	1,588249619	0,514959632	-0,008988654	0,857167301	joint
surface	60	53	0,523598776	-2,21656815	-0,399317755	-0,300907512	0,866025404	joint
surface	30	277	1,047197551	1,692969374	0,859570182	-0,105541947	0,5	joint
surface	89	355	0,017453293	3,054326191	0,001521077	-0,017385995	0,999847695	joint
surface	87	30	0,052359878	-2,617993878	-0,026167978	-0,045324268	0,998629535	joint
surface	80	322	0,174532925	2,478367538	0,106908493	-0,136836631	0,984807753	joint
surface	89	40	0,017453293	-2,443460953	-0,011218191	-0,013369319	0,999847695	joint
surface	87	338	0,052359878	2,757620218	0,019605394	-0,048525054	0,998629535	joint
surface	80	333	0,174532925	2,670353756	0,078834623	-0,154721659	0,984807753	joint
surface	66	88	0,41887902	-1,605702912	-0,40648887	-0,014194904	0,913545458	joint
surface	78	343	0,20943951	2,844886681	0,060787495	-0,198826939	0,978147601	joint
surface	18	45	1,256637061	-2,35619449	-0,672498512	-0,672498512	0,309016994	joint
surface	41	274	0,855211333	1,640609497	0,752871146	-0,052645879	0,656059029	joint
surface	72	55	0,314159265	-2,181661565	-0,253131903	-0,177244866	0,951056516	joint
surface	67	54	0,401425728	-2,199114858	-0,316108123	-0,229665995	0,920504853	joint
surface	70	212	0,34906585	0,558505361	0,181243063	0,290049531	0,939692621	joint
surface	85	211	0,087266463	0,541052068	0,044888526	0,074707053	0,996194698	joint
surface	38	280	0,907571211	1,745329252	0,7760391	-0,136836631	0,615661475	joint
surface	71	60	0,331612558	-2,094395102	-0,281950292	-0,162784077	0,945518576	joint
surface	88	211	0,034906585	0,541052068	0,01797457	0,029914707	0,999390827	joint
surface	83	215	0,122173048	0,610865238	0,069901384	0,099829522	0,992546152	joint
surface	63	273	0,471238898	1,623156204	0,453368322	-0,023760027	0,891006524	joint
surface	60	33	0,523598776	-2,565634	-0,272319518	-0,419335284	0,866025404	joint
surface	40	278	0,872664626	1,710422667	0,758589351	-0,106612781	0,64278761	joint
surface	26	270	1,117010721	1,570796327	0,898794046	5,50578E-17	0,438371147	joint
surface	70	53	0,34906585	-2,21656815	-0,273149432	-0,20583286	0,939692621	joint
surface	82	218	0,13962634	0,663225116	0,085683517	0,1096699	0,990268069	joint
surface	45	244	0,785398163	1,117010721	0,635543365	0,309975211	0,707106781	joint
surface	41	258	0,855211333	1,361356817	0,738217365	0,156912945	0,656059029	joint
surface	72	55	0,314159265	-2,181661565	-0,253131903	-0,177244866	0,951056516	joint
surface	67	52	0,401425728	-2,234021443	-0,307900331	-0,240558103	0,920504853	joint
surface	53	56	0,645771823	-2,164208272	-0,498927266	-0,33653069	0,79863551	joint
surface	83	285	0,122173048	1,832595715	0,117716746	-0,031542107	0,992546152	joint
surface	67	58	0,401425728	-2,129301687	-0,33135879	-0,207055952	0,920504853	joint
surface	38	265	0,907571211	1,483529864	0,785012135	0,068679663	0,615661475	joint
surface	63	41	0,471238898	-2,42600766	-0,297844566	-0,342630979	0,891006524	joint
surface	82	30	0,13962634	-2,617993878	-0,06958655	-0,120527441	0,990268069	joint
surface	89	309	0,017453293	2,251474735	0,013563067	-0,010983155	0,999847695	joint
surface	80	33	0,174532925	-2,565634	-0,094575576	-0,145633616	0,984807753	joint
surface	88	353	0,034906585	3,019419606	0,004253179	-0,034639361	0,999390827	joint
surface	38	273	0,907571211	1,623156204	0,786930812	-0,041241296	0,615661475	joint
surface	62	31	0,488692191	-2,600540585	-0,24179573	-0,402415672	0,882947593	joint
surface	60	53	0,523598776	-2,21656815	-0,399317755	-0,300907512	0,866025404	joint
surface	78	211	0,20943951	0,541052068	0,107082437	0,178215103	0,978147601	joint
surface	53	38	0,645771823	-2,478367538	-0,370514325	-0,47423671	0,79863551	joint

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
surface	85	218	0,087266463	0,663225116	0,053658433	0,068679663	0,996194698	joint
surface	85	208	0,087266463	0,488692191	0,040917143	0,076953953	0,996194698	joint
surface	88	222	0,034906585	0,733038286	0,023352321	0,02593538	0,999390827	joint
surface	73	54	0,296705973	-2,199114858	-0,236533678	-0,171851776	0,956304756	joint
surface	66	52	0,41887902	-2,234021443	-0,320512849	-0,250412082	0,913545458	joint
surface	48	247	0,733038286	1,169370599	0,615937971	0,261450157	0,743144825	joint
surface	75	46	0,261799388	-2,338741198	-0,18617884	-0,179790816	0,965925826	joint
surface	84	32	0,104719755	-2,583087293	-0,055391646	-0,088645164	0,994521895	joint
surface	37	263	0,925024504	1,448623279	0,792682602	0,097329185	0,601815023	joint
surface	63	58	0,471238898	-2,129301687	-0,385005779	-0,240578312	0,891006524	joint
surface	82	158	0,13962634	-0,383972435	-0,052135161	0,129039052	0,990268069	joint
surface	65	38	0,436332313	-2,478367538	-0,260189783	-0,333027735	0,906307787	joint
surface	88	221	0,034906585	0,715584993	0,02289613	0,026338985	0,999390827	joint
surface	85	214	0,087266463	0,593411946	0,048736873	0,072255385	0,996194698	joint
surface	73	54	0,296705973	-2,199114858	-0,236533678	-0,171851776	0,956304756	joint
surface	72	210	0,314159265	0,523598776	0,154508497	0,267616567	0,951056516	joint
surface	40	282	0,872664626	1,780235837	0,749304534	-0,159269595	0,64278761	joint
surface	68	167	0,383972435	-0,226892803	-0,084268148	0,365005451	0,927183855	joint
surface	74	55	0,27925268	-2,181661565	-0,225788903	-0,158099092	0,961261696	joint
surface	80	38	0,174532925	-2,478367538	-0,106908493	-0,136836631	0,984807753	joint
surface	88	23	0,034906585	-2,740166926	-0,01363632	-0,032125156	0,999390827	joint
surface	83	28	0,122173048	-2,652900463	-0,057214191	-0,107604243	0,992546152	joint
surface	79	171	0,191986218	-0,157079633	-0,029849103	0,18845982	0,981627183	joint
surface	78	25	0,20943951	-2,705260341	-0,087867277	-0,188431984	0,978147601	joint
surface	79	23	0,191986218	-2,740166926	-0,074555014	-0,175640606	0,981627183	joint
surface	78	38	0,20943951	-2,478367538	-0,128003218	-0,163836648	0,978147601	joint
surface	72	11	0,314159265	-2,949606436	-0,058963222	-0,303339482	0,951056516	joint
surface	56	13	0,593411946	-2,914699851	-0,125791033	-0,544860826	0,829037573	joint
surface	56	13	0,593411946	-2,914699851	-0,125791033	-0,544860826	0,829037573	joint
surface	65	58	0,436332313	-2,129301687	-0,358400612	-0,223953558	0,906307787	joint
surface	76	200	0,244346095	0,34906585	0,082742161	0,22733222	0,970295726	joint
surface	81	213	0,157079633	0,575958653	0,085200316	0,131196982	0,987688341	joint
surface	85	216	0,087266463	0,628318531	0,05122886	0,070510477	0,996194698	joint
surface	88	247	0,034906585	1,169370599	0,032125156	0,01363632	0,999390827	joint
surface	79	278	0,191986218	1,710422667	0,188952055	-0,02655548	0,981627183	joint
surface	37	118	0,925024504	-1,082104136	-0,705153301	0,374936661	0,601815023	joint
surface	81	218	0,157079633	0,663225116	0,096310674	0,123272041	0,987688341	joint
surface	87	210	0,052359878	0,523598776	0,026167978	0,045324268	0,998629535	joint
surface	87	208	0,052359878	0,488692191	0,024570243	0,046209907	0,998629535	joint
surface	71	101	0,331612558	-1,378810109	-0,31958655	0,062121332	0,945518576	joint
surface	89	28	0,017453293	-2,652900463	-0,008193409	-0,01540956	0,999847695	joint
surface	82	210	0,13962634	0,523598776	0,06958655	0,120527441	0,990268069	joint
surface	44	280	0,802851456	1,745329252	0,708411412	-0,124912045	0,69465837	joint
surface	85	223	0,087266463	0,750491578	0,059440074	0,063741675	0,996194698	joint
surface	80	208	0,174532925	0,488692191	0,081522881	0,15332224	0,984807753	joint
surface	85	18	0,087266463	-2,827433388	-0,026932606	-0,082890037	0,996194698	joint
surface	87	37	0,052359878	-2,49582083	-0,031496565	-0,041797353	0,998629535	joint
surface	87	246	0,052359878	1,151917306	0,047811275	0,021286951	0,998629535	joint
surface	81	59	0,157079633	-2,111848395	-0,134090508	-0,080569706	0,987688341	joint
surface	80	53	0,174532925	-2,21656815	-0,138681601	-0,104504082	0,984807753	joint
surface	85	171	0,087266463	-0,157079633	-0,013634162	0,086082711	0,996194698	joint
surface	70	330	0,34906585	2,617993878	0,171010072	-0,296198133	0,939692621	joint
surface	89	333	0,017453293	2,670353756	0,007923227	-0,015550208	0,999847695	joint
surface	33	272	0,994837674	1,605702912	0,838159672	-0,029269181	0,544639035	joint
surface	75	207	0,261799388	0,471238898	0,117501388	0,230609458	0,965925826	joint
surface	51	156	0,680678408	-0,41887902	-0,255967663	0,574912785	0,777145961	joint
surface	88	319	0,034906585	2,42600766	0,02289613	-0,026338985	0,999390827	joint

depth (meter)	measures		θ	ϕ	cosine director			geological structure
	dip	dipdirection			x	y	z	
surface	65	158	0,436332313	-0,383972435	-0,158315587	0,391844829	0,906307787	joint
surface	83	201	0,122173048	0,366519143	0,043674067	0,113774834	0,992546152	joint
surface	46	50	0,767944871	-2,268928028	-0,532139185	-0,446517793	0,7193398	joint
surface	52	48	0,663225116	-2,303834613	-0,45752564	-0,411957936	0,788010754	joint
surface	65	35	0,436332313	-2,530727415	-0,242403877	-0,346188613	0,906307787	joint
surface	82	23	0,13962634	-2,740166926	-0,054379263	-0,128109515	0,990268069	joint
surface	80	25	0,174532925	-2,705260341	-0,073386891	-0,157378696	0,984807753	joint
surface	53	204	0,645771823	0,41887902	0,244780222	0,549785381	0,79863551	joint
surface	66	352	0,41887902	3,001966313	0,0566068	-0,40277831	0,913545458	joint
surface	52	272	0,663225116	1,605702912	0,615286431	-0,021486276	0,788010754	joint
surface	89	223	0,017453293	0,750491578	0,011902513	0,012763882	0,999847695	joint
surface	84	205	0,104719755	0,436332313	0,044175637	0,09473496	0,994521895	joint
surface	87	240	0,052359878	1,047197551	0,045324268	0,026167978	0,998629535	joint
surface	77	47	0,226892803	-2,321287905	-0,164518786	-0,15341625	0,974370065	joint
surface	87	43	0,052359878	-2,391101075	-0,035693036	-0,038276095	0,998629535	joint
surface	48	276	0,733038286	1,675516082	0,665465039	-0,069943194	0,743144825	joint
surface	81	27	0,157079633	-2,670353756	-0,071019761	-0,139384129	0,987688341	joint
surface	77	210	0,226892803	0,523598776	0,112475527	0,194813328	0,974370065	joint
surface	54	274	0,628318531	1,640609497	0,586353437	-0,041001827	0,809016994	joint
surface	56	279	0,593411946	1,727875959	0,552308311	-0,087477043	0,829037573	joint
surface	65	62	0,436332313	-2,059488517	-0,373149777	-0,198407256	0,906307787	joint
surface	47	239	0,750491578	1,029744259	0,584586693	0,351255122	0,731353702	joint
surface	89	92	0,017453293	-1,535889742	-0,017441775	0,00060908	0,999847695	joint
surface	89	91	0,017453293	-1,553343034	-0,017449748	0,000304586	0,999847695	joint
surface	89	92	0,017453293	-1,535889742	-0,017441775	0,00060908	0,999847695	joint
surface	89	118	0,017453293	-1,082104136	-0,01540956	0,008193409	0,999847695	joint
surface	89	120	0,017453293	-1,047197551	-0,015114227	0,008726203	0,999847695	joint
surface	88	209	0,034906585	0,506145483	0,016919612	0,030523788	0,999390827	joint
surface	88	210	0,034906585	0,523598776	0,017449748	0,030223851	0,999390827	joint
surface	89	210	0,017453293	0,523598776	0,008726203	0,015114227	0,999847695	joint
surface	89	217	0,017453293	0,645771823	0,01050312	0,013938112	0,999847695	joint
surface	89	244	0,017453293	1,117010721	0,015686119	0,007650631	0,999847695	joint
surface	64	255	0,453785606	1,308996939	0,423434012	0,113458802	0,898794046	joint
surface	88	300	0,034906585	2,094395102	0,030223851	-0,017449748	0,999390827	joint
surface	75	337	0,261799388	2,740166926	0,101128658	-0,238244187	0,965925826	joint
surface	89	10	0,017453293	-2,967059728	-0,003030579	-0,017187265	0,999847695	joint
surface	84	35	0,104719755	-2,530727415	-0,059955063	-0,085624704	0,994521895	joint
surface	76	65	0,244346095	-2,00712864	-0,219255698	-0,102240611	0,970295726	joint
surface	80	75	0,174532925	-1,832595715	-0,167731259	-0,044943456	0,984807753	joint

Supplementary Material 2

```
dados= read.csv("Dados_Totais_Prof.csv",sep=";")
dados_frat = dados[dados$estrutura=="fratura",]
dados_fol = dados[dados$estrutura=="foliacao",]
dados_fratura = read.csv("fratura.csv",sep=";")

#Usando lm (regressao multivariada)
X = dados_4d$x
Y = dados_4d$y
Z = dados_4d$z
estr = factor(dados_4d$estrutura)
prof = (as.numeric(dados_4d$profundidade))

fit.lm <- lm(cbind(x,y,z)~as.numeric(profundidade)+estrutura+as.numeric(profundidade)*estrutura, data = dados_4d)

summary(fit.lm, multivariate=TRUE)

#diagnostico
plot(fit.lm$fitted.values[,1],fit.lm$residuals[,1],xlab = "Valor ajustado de X", ylab = "Resíduo")
plot(fit.lm$fitted.values[,2],fit.lm$residuals[,2],xlab = "Valor ajustado de y", ylab = "Resíduo")
plot(fit.lm$fitted.values[,3],fit.lm$residuals[,3],xlab = "Valor ajustado de z", ylab = "Resíduo")
car::qqPlot(as.numeric(fit.lm$residuals[,1]),ylab = "Resíduo de x")
car::qqPlot(as.numeric(fit.lm$residuals[,2]),ylab = "Resíduo de y")
car::qqPlot(as.numeric(fit.lm$residuals[,3]),ylab = "Resíduo de z")


#como deu interacao, vamos separar as estruturas:
dados_fol = dados[dados$estrutura=="foliacao",]

scatter3D(dados_fol$x,dados_fol$y,dados_fol$z,colvar=FALSE,col = "blue")

#T1

estr = factor(dados_4d$estrutura)
prof = (as.numeric(dados_4d$profundidade))
fit.lm_fol = lm(cbind(x,y,z)~profundidade, data = dados_fol)

#diagnostico
```

```
plot(fit.lm_fol$fitted.values[,1],fit.lm_fol$residuals[,1],xlab = "Valor ajustado de X", ylab = "Resíduo",main ="Numérico")
plot(fit.lm_fol$fitted.values[,2],fit.lm_fol$residuals[,2],xlab = "Valor ajustado de y", ylab = "Resíduo",main ="Numérico")
plot(fit.lm_fol$fitted.values[,3],fit.lm_fol$residuals[,3],xlab = "Valor ajustado de z", ylab = "Resíduo",main ="Numérico")
car::qqPlot(as.numeric(fit.lm_fol$residuals[,1]),main ="Numérico")
car::qqPlot(as.numeric(fit.lm_fol$residuals[,2]),main ="Numérico")
car::qqPlot(as.numeric(fit.lm_fol$residuals[,3]),main ="Numérico")


#usando funcao manova
X = dados_4d$x
Y = dados_4d$y
Z = dados_4d$z
aux_prof = dados_4d$aux

fit.lmX = lm(as.numeric(X)~factor(aux_prof)+factor(etsr)+factor(aux_prof)*factor(estr))
plot(as.numeric(X),fit.lmX$residuals)
car::qqPlot(fit.lmX$residuals)
fit.lmX = lme(as.numeric(X)~factor(aux_prof)+factor(etsr)+factor(aux_prof)*factor(estr))

fit.lm = lm(cbind(x,y,z)~factor(sup_prof)+factor(estrutura) + factor(estrutura)*factor(sup_prof), data=dados)
fit.manova <- Manova(fit.lm)
summary(fit.manova, multivariate=TRUE)
summary(fit2.manova)
summary(fit2.lm)

#diagnostico
par(mfrow=c(1,1))
plot(fit.lm$fitted.values[,1],fit.lm$residuals[,1], xlab = "Valor ajustado de X", ylab = "Resíduo")
plot(fit.lm$fitted.values[,2],fit.lm$residuals[,2], xlab = "Valor ajustado de y", ylab = "Resíduo")
plot(fit.lm$fitted.values[,3],fit.lm$residuals[,3], xlab = "Valor ajustado de z", ylab = "Resíduo")

par(mfrow=c(1,1))
car::qqPlot(fit.lm$residuals[,1],envelope=.95,ylab = "Resíduos", main = "X")
car::qqPlot(fit.lm$residuals[,2],envelope=.95,ylab = "Resíduos", main = "Y")
car::qqPlot(fit.lm$residuals[,3],envelope=.95,ylab = "Resíduos", main = "Z")

#separados
```

```
fit.lm = lm(cbind(x,y,z)~factor(sup_prof), data=dados_fol)
fit.manova <- Manova(fit.lm)
summary(fit.manova, multivariate=TRUE)
summary(fit2.manova)
summary(fit2.lm)


par(mfrow=c(1,1))
plot(fit.lm$fitted.values[,1],fit.lm$residuals[,1], xlab = "Valor ajustado de x", ylab = "Resíduo")
plot(fit.lm$fitted.values[,2],fit.lm$residuals[,2], xlab = "Valor ajustado de y", ylab = "Resíduo")
plot(fit.lm$fitted.values[,3],fit.lm$residuals[,3], xlab = "Valor ajustado de z", ylab = "Resíduo")

par(mfrow=c(1,1))
car::qqPlot(fit.lm$residuals[,1],envelope=.95,ylab = "Resíduos", main = "X")
car::qqPlot(fit.lm$residuals[,2],envelope=.95,ylab = "Resíduos", main = "Y")
car::qqPlot(fit.lm$residuals[,3],envelope=.95,ylab = "Resíduos", main = "Z")
```

Supplementary Material 3

```
dados= read.csv("Dados_Totais_Prof.csv",sep=";")
dados_frat_sup = dados_frat[dados_frat$sup_prof==1,]
dados_frat_prof = dados_frat[dados_frat$sup_prof==2,]
dados_fol_sup = dados_fol[dados_fol$sup_prof==1,]
dados_fol_prof = dados_fol[dados_fol$sup_prof==2,]
dados_sup = dados[dados$sup_prof==1,]
dados_prof = dados[dados$sup_prof==2,]

#Verificando que as variancias sao distintas
biotools::boxM(dados[,6:8],factor(dados$sup_prof))
biotools::boxM(dados_fol[,6:8],factor(dados_fol$sup_prof))
biotools::boxM(dados_frat[,6:8],factor(dados_frat$sup_prof))

#funcoes auxiliares
teto_max = function(valor){
  teto = 1
  if(valor < 1){
    teto = valor
  }
```

```
  teto
}

piso_min = function(valor){
  piso = -1
  if(piso < -1){
    piso = valor
  }
  valor
}

#Gera regioes de confiança com default de p-valor=5% e m=1000000 pontos simulados e k graus de liberdade
mi_ic = function(dados,quantil=0.95,m=1000000,k){
  mi = NULL
  xyz = cbind(dados$x,dados$y,dados$z)
  n = length(dados$x)
  xyz_bar = rbind(mean(dados$x),mean(dados$y),mean(dados$z))
  var_xyz = diag(cov(xyz))
  x_ic = c(piso_min(xyz_bar[1]-2*var_xyz[1]),teto_max(xyz_bar[1]+2*var_xyz[1]))
  y_ic = c(piso_min(xyz_bar[2]-2*var_xyz[2]),teto_max(xyz_bar[2]+2*var_xyz[2]))
  z_ic = c(piso_min(xyz_bar[3]-2*var_xyz[3]),teto_max(xyz_bar[3]+2*var_xyz[3]))
  x_tilde = xyz[1,]-xyz_bar
  for(i in 2:n){
    x_tilde = cbind(x_tilde,xyz[i,]-xyz_bar)
  }
  S0 = x_tilde%*%t(x_tilde)
  S0_inv = solve(S0)*n
  for(j in 1:m){
    mi_new = c(runif(1,min=x_ic[1],max=x_ic[2]),runif(1,min=y_ic[1],max=y_ic[2]),runif(1,min=z_ic[1],max=z_ic[2]))
    central = t(xyz_bar-mi_new)
    A = central%*%S0_inv%*%t(central)
    if(A<k){
      mi = cbind(mi,mi_new)
    }
  }
  mi = as.data.frame(mi)
}
range_mi = function(mi){
```

```
  range_x = c(min(mi$x)-0.01,max(mi$x)+0.01)
  range_y = c(min(mi$y)-0.01,max(mi$y)+0.01)
  range_z = c(min(mi$z)-0.01,max(mi$z)+0.01)
  limits = t(rbind(range_x,range_y,range_z))
  limits = as.data.frame(limits)
  colnames(limits) = c("x","y","z")
  rownames(limits) = c("min","max")
  limits
}

#elipsoide geral
##calculo da constante ck
n = length(dados_sup$x)
n2 = length(dados_prof$x)
quantil = 0.95
ck = 3/(n+n2-3)*qf(quantil,3,n+n2-3)
##simulacao dos pontos de superficie e profundidade
mi_sup = mi_ic(dados_sup,k=ck)
mi_prof = mi_ic(dados_prof,k=ck)
##categorizacao dos pontos
mi_sup_cat = rbind(mi_sup,1)
mi_prof_cat = rbind(mi_prof,2)
mi_tot = as.data.frame(t(cbind(mi_sup_cat,mi_prof_cat)))
colnames(mi_tot) = c("x","y","z","sup_prof")
range_mi_mi_tot = range_mi(mi_tot)
##plot
plot3d(mi_tot$x,mi_tot$y,mi_tot$z, xlim = range_mi_mi_tot$x,ylim = range_mi_mi_tot$y,zlim =
range_mi_mi_tot$z,col=mi_tot$sup_prof)

#elipsoide para foliacao
##calculo da constante ck
n = length(dados_fol_sup$x)
n2 = length(dados_fol_prof$x)
ck = 3/(n+n2-3)*qf(quantil,3,n+n2-3)
##simulacao dos pontos de superficie e profundidade
mi_fol_sup = mi_ic(dados_fol_sup,k=ck)
mi_fol_prof = mi_ic(dados_fol_prof,k=ck)
##categorizacao dos pontos
mi_fol_sup_cat = rbind(mi_fol_sup,1)
```

```
mi_fol_prof_cat = rbind(mi_fol_prof,2)
mi_fol_tot = as.data.frame(t(cbind(mi_fol_sup_cat,mi_fol_prof_cat)))
colnames(mi_fol_tot) = c("x","y","z","sup_prof")
range_mi_mi_tot = range_mi(mi_fol_tot)
##plot
plot3d(mi_fol_tot$x,mi_fol_tot$y,mi_fol_tot$z, xlim = range_mi_mi_tot$x,ylim = range_mi_mi_tot$y,zlim = range_mi_mi_tot$z,col=mi_fol_tot$sup_prof,xlab="x",ylab="y",zlab="z")


#elipsoide para fratura
##calculo da constante ck
n = length(dados_frat_sup$x)
n2 = length(dados_frat_prof$x)
ck = 3/(n+n2-3)*qf(quantil,3,n+n2-3)
##simulacao dos pontos de superficie e profundidade
mi_frat_sup = mi_ic(dados_frat_sup,k=ck)
mi_frat_prof = mi_ic(dados_frat_prof,k=ck)
##categorizacao dos pontos
mi_frat_sup_cat = rbind(mi_frat_sup,1)
mi_frat_prof_cat = rbind(mi_frat_prof,2)
mi_frat_tot = as.data.frame(t(cbind(mi_sup_cat,mi_prof_cat)))
range_mi_mi_tot = range_mi(mi_frat_tot)
colnames(mi_frat_tot) = c("x","y","z","sup_prof")
plot3d(mi_frat_tot$x,mi_frat_tot$y,mi_frat_tot$z, xlim = range_mi_mi_tot$x,ylim = range_mi_mi_tot$y,zlim = range_mi_mi_tot$z,col=mi_frat_tot$sup_prof,xlab="x",ylab="y",zlab="z")
```

Supplementary Material 4

```
dados= read.csv("Dados_Totais_Prof.csv",sep=";")
dados_frat = dados[dados$estrutura=="fratura",]
dados_fol = dados[dados$estrutura=="foliacao",]
dados_frat_sup = dados_frat[dados_frat$sup_prof==1,]
dados_frat_prof = dados_frat[dados_frat$sup_prof==2,]
dados_fol_sup = dados_fol[dados_fol$sup_prof==1,]
dados_fol_prof = dados_fol[dados_fol$sup_prof==2,]
dados_sup = dados[dados$sup_prof==1,]
dados_prof = dados[dados$sup_prof==2,]

tr = function(matriz){
```

```
  sum(diag(matriz))
}

qhotelling = function(p,v){
  qf(p,3,v-3)*(v-1)*3/(v-3)
}

#Dá o quantil da T2 de Hotelling associada
quantil_T2 = function(dados,quantil){
  dados_s = dados[dados$sup_prof==1,]
  dados_p = dados[dados$sup_prof==2,]
  xyz_s = cbind(dados_s$x,dados_s$y,dados_s$z)
  xyz_p = cbind(dados_p$x,dados_p$y,dados_p$z)
  n1 = length(xyz_s[,1])
  n2 = length(xyz_p[,1])
  xyz_bar_s = cbind(mean(xyz_s[,1]),mean(xyz_s[,2]),mean(xyz_s[,3]))
  xyz_bar_p = cbind(mean(xyz_p[,1]),mean(xyz_p[,2]),mean(xyz_p[,3]))
  S1 = cov(xyz_s)/n1
  S2 = cov(xyz_p)/n2
  mid_fol = S1+S2
  mid_fol_inv = solve(mid_fol)
  v = (tr(mid_fol%*%mid_fol)+(tr(mid_fol))^2)/((tr(S1%*%S1)+(tr(S1))^2)/(n1-1)) + ((tr(S2%*%S2)+(tr(S2))^2)/(n2-1))
  qhotelling(quantil,v)
}

quantil_T2(dados_fol,0.95)

#construindo a estatística T^2 de Hotelling
n_fol_sup = length(xyz_fol_sup[,1])
n_fol_prof = length(xyz_fol_prof[,1])
xyz_fol_sup_bar = cbind(mean(xyz_fol_sup[,1]),mean(xyz_fol_sup[,2]),mean(xyz_fol_sup[,3]))
xyz_fol_prof_bar = cbind(mean(xyz_fol_prof[,1]),mean(xyz_fol_prof[,2]),mean(xyz_fol_prof[,3]))
S_fol_sup = cov(xyz_fol_sup)/n_fol_sup
S_fol_prof = cov(xyz_fol_prof)/n_fol_prof
mid_fol = S_fol_sup+S_fol_prof
mid_fol_inv = solve(mid_fol)
diff = xyz_fol_sup_bar-xyz_fol_prof_bar
T2_fol = diff%*%mid_fol_inv%*%t(diff)
```

```
#Calculando graus de liberdade aproximados
v = (tr(mid_fol%*%mid_fol)+(tr(mid_fol))^2)/((tr(S_fol_sup%*%S_fol_sup)+(tr(S_fol_sup))^2)/(n_fol_sup-1)) + ((tr(S_fol_prof%*%S_fol_prof)+(tr(S_fol_prof))^2)/(n_fol_prof-1))
#fixando o quantil 0.95 da v.a. T^2 de Hotelling
k = qhotelling(.95,v)
T2_fol

diag(S_fol_sup)[1]/diag(S_fol_prof)[1]
diag(S_fol_sup)[2]/diag(S_fol_prof)[2]
diag(S_fol_sup)[3]/diag(S_fol_prof)[3]

#install.packages("biotools")
#Verificando que as variancias sao distintas
library("biotools")
biotools::boxM(dados[,6:8],factor(dados$sup_prof))
biotools::boxM(dados_fol[,6:8],factor(dados_fol$sup_prof))
biotools::boxM(dados_frat[,6:8],factor(dados_frat$sup_prof))

#testes (verificando as diferenças)
ICSNP::HotellingsT2(xyz_sup,xyz_prof, test = "chi")
ICSNP::HotellingsT2(xyz_frat_sup,xyz_frat_prof, test = "chi")
ICSNP::HotellingsT2(xyz_fol_sup,xyz_fol_prof, test = "chi")
```

References

Anderson, M. J., Walsh, D.C.I. (2013) PERMANOVA, ANOSIM, and the Mantel test in the face of heterogeneous dispersions: What null hypothesis are you testing? Ecological Monographs, 83(4), pp. 557–574.

Ang, A.H.S., Tang, W. (2007) Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering. John Wiley & Sons, New York, USA, 420 p.

Costa, E.A. (2005) Avaliação de ameaças e risco geotécnico aplicados à estabilidade de taludes. Dissertação de Mestrado, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, 160 p.

Fisher N. I., Lewis T., Embleton, B. J. J. (1993) Statistical analysis of spherical data. Cambridge University Press, New York, USA, 320 p.

Ge, H., Tu, J., Qin, F. (2011) Analysis of Slope Stability with First Order Second Moment Method. International Journal of Digital Content Technology and its Applications 5(12): 445-451.

Härdle, W. K. and Simar, L. (2012) Applied Multivariate Statistical Analysis. 3° Ed., Springer Heidelberg Dordrecht London New York, USA 516 p.

Hasui, Y., Mioto J.A. (1992) Geologia Estrutural Aplicada, São Paulo, ABGE Associação Brasileira de Geologia de Engenharia e S.A. Indústrias Votorantim.

Hoek, E., Kaiser, P.K.,Bawden,,W.F. (1997) Support of Underground Excavations in Hard Rock. Ed. Balkema 215p.

Hudson, J.A. e Feng, X.T. (2015) Rock Engineering Risk. CRC Press 572 p.

Johnson, R.A., Wischern, D.W. (2007) Applied Multivariate Statistical Analysis, Pearson Prentice Hall, 6th edition p. 284-312.

Krueger, J. I., and Heck, P. R. (2019) Putting the p-value in its place. *The American Statistician*, *73* (sup1), 122-128.

Mardia. K. V., (1972) Statistics of Directional Data. Academic Press, London.

Mardia, K.V., Kent, J. T., Bibby, J. M. (1995) Multivariate Analysis, Academic Press, 2° edition.

Montoya, C.A.H. & Assis, A.P. (2011b) Tools for reliability analysis in geotechnical engineering: application (in Spanish). Revista Ingenierías Universidad de Medellín, 10 (18): 79-86.

Pacheco, F.E.R.C., Serrano, M.S., Caxito, F.A., Moura, C.D., Quintão, D.A. (2017) Programa Mapeamento Geológico do Estado de Minas Gerais – Projeto Triângulo Mineiro: Folha de Uberlândia. Instituto de Geociências UFMG.

Pastore, E. L., Fontes, R. M., Oliveira, A. M. S., & Brito, S. N. A. (1998) Geologia de Engenharia. Caracterização e Classificação de Solos Cap.12, 197-210.

Pimentel M.M., Fuck R.A., Botelho N.F., (1999) Granites and the geodynamic history of the Brasília Belt, central Brazil: a review. *Lithos*, 46:463-483.

Pimentel M.M. (2016) The tectonic evolution of the Neoproterozoic Brasília Belt, central Brazil: a geochronological and isotopic approach. *Brazilian Journal of Geology*, 2016, 46 (Suppl 1):67-82.

Sadowski, G.R. (2014) Previsibilidade e Risco em Geologia Geotécnica. In Direito da Construção, Org. Fernando Marcondes, Editora Pini. pp. 271-281.

Strieder A.J. & Nilson A.A. (1992) Mélange ofiolítica nos metassedimentos do Grupo Araxá de Abadiânia (GO) e implicações tectônicas regionais. *Revista Brasileira de Geociências*, 22:204-215.

Valeriano, C. M., (1993) Evolução tectônica da extremidade meridional da faixa Brasília, região da represa de Furnas, sudoeste de Minas Gerais. Tese de Doutorado, Instituto de Geociências, Universidade de São Paulo. São Paulo, Doi: 10.11606/T.44.1993.tde-23062015-140732.