PETROLEUM RESERVOIR CHARACTERIZATION

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ABSTRACT

The reservoir simulation in the oil industry has become the standard for the solution of engineering problems of reservoirs. There have been several developed simulators and recovery processes are being developed for new oil recovery processes. The reservoir simulation is the art of combining physics, mathematics, reservoir engineering, and computer programming to develop a tool to predict the performance of hydrocarbon reservoirs in various operations strategies.

Therefore, modeling systems or oil reservoirs have a great importance on the development and implementation of mathematical and stochastic models for the characterization of petroleum reservoirs. It consists in building a computer model of an oil reservoir for the purpose of improving the estimation of reserves and making decisions about the development of the field. They are called mathematical and geostatistical models and their main purpose is to characterize petroleum reservoirs worldwide. That is, through computerized images of the deposits, it is possible to have an accurate picture of the field permeability, porosity and the amount of existing oil. These models, which reflect not only the knowledge of the internal characteristics of the reservoir (porosity, permeability, fracture systems and faults, contact oil / water) but the uncertainty associated with them.

This work consistis at the study of reservoir characterization and quantification of uncertainties of an oil field, through the analysis of two methodologies to be applied in a practical case study.

KEYWORDS

Petroleum reservoir

Porosity

Permeability

Direct sequential simulation (DSS)

Direct sequential Co-simulation (CO-DSS)

Uncertainty

I.INTRODUCTION

Oil is an abundant natural resource, but its research involves high costs and complexity of studies. It is also currently the main source of energy, serving as a base for the manufacturation of various products, among which are benzene, diesel, gasoline, tar, plastics polymers and even medicines. It was the cause of many wars and is the main source of income for many countries, particularly in the Middle East.

In addition to generating the gas which serves as fuel for most of the cars circulating in the world, several products are derived from petroleum, for example, paraffin, LPG, asphalt products, petrochemical naphtha, kerosene, solvents, fuel oils, lubricating oils , diesel and jet fuel.

Oil hardly loses his position as world fuel. In addition to being dominant in the transport sector is still largely responsible for the generation of electricity in several countries.

The reservoir engineering disciplines is a key input to the planning of oilfield development. It covers a very wide area of knowledge in the oil industry. They go through this course the answers to the basic questions of a development plan for an oil field.

The reservoir characterization involves a set of processes that define the quantitative distribution of their properties and reveal the uncertainties according to their spatial variability, in order to predict the flow behavior in the reservoir. Geostatistics arises in this context as a tool that aids in the incorporation of geological concepts in two-dimensional and three-dimensional representations. This is important because it allows us to observe the heterogeneity of the reservoirs, their directions of continuity, the result of deposition conditions, structural and diagenetic processes.

Geostatistics also plays an important role in the characterization of petroleum reservoirs, because it offers a set of deterministic and statistical tools to understand and model the spatial variability (Deutsch and Journel). When data are scarce, the Geostatistics methods provide better results. When properly applied, is a powerful tool in the characterization and modeling of petroleum reservoirs. It presents different methods of calculations, which can be classified into two categories: estimation and simulation (Gomes, 2007).

The geostatistical methods allow you to increase the accuracy of estimates of the main variable using information available from other spatially correlated secondary variables. Conditional Simulation Methods Geostatistics describe the local variability of the data, based on many equiprobable simulations of the phenomenon, consistent with the data and their statistical properties reproduce the variance and spatial correlation of the sample data and thus provide an estimate of the possible values of attribute in locations not sampled. So that the spacial uncertainty can be evaluated using probability maps, charts and maps of quantile dispersion. These maps do not depend on the geometrical configuration of the samples, but of their local values (Deutsch and Journel).

I.1. OBJECTIVES

This work aims at studying the petroleum reservoir characterization and uncertainty analysis of the same. To study the characterization of petroleum reservoirs are discussed theoretical issues and is made a short resume on the most important aspects to consider during the process of characterizing a reservoir. For the study and analysis of the uncertainty has been taken a case study (Pontiguar Basin, training Açu) in which t is made the study of two methodologies that are designed to estimate the uncertainty of the permeability and porosity, these methods are direct sequential simulation and direct sequential co-simulation. Therefore it is proposed to make the comparison between these two methods of stochastic simulation for the oil field data adopted for this study and see which one is the best estimator.

II.THE CHARACTERIZATION OF THE RESERVOIR

The characterization of a petroleum reservoir is based on geological and petrophysical description of it, i.e., the distribution of properties such as permeability, porosity, overruns, etc. A good characterization of reservoir heterogeneities is a fundamental requirement for a prediction of their behavior. The key is to characterize the reservoir as best as possible, preserving the heterogeneity of the same whatever its scale. Only then we can study and predict the movement of hydrocarbons in the reservoir, which is controlled primarily by petrophysical extreme values, i.e. by the maximum and minimum values. If you use average values, the recovery factors resulting from reservoir studies are usually too optimistic (Gomes, 2007).

II.1. Reservoir simulation

In reality reservoir simulation, is no more than a methodology, a valuable tool to predict the behavior of petroleum reservoirs variations that relates the pressure of the reservoir with the levels of production and injection, with the reserves and the properties of the rock and fluids, such as porosity, saturation and permeability (Gomes, 2007).

II.2. Geostatistics ... its importance in the characterization of petroleum reservoirs

The Geostatistics when properly applied is a powerful tool in the characterization and modeling of petroleum reservoirs (Gomes, 2007). It presents different methods of calculations, which can be classified into two categories: estimation and simulation. Both techniques use variograms or correlograms to measure the spatial continuity of petrophysical variable determined.

However, the results give a Geostatistical image of reality, so far from this or closer, the more reliable and appropriate variables are chosen as representative of reality. Finally, geostatistics addresses some types of problems but does not solve all problems. In most situations, a geostatistical study is part of a multidisciplinary approach. Although geostatistics requires the application of statistics and mathematics, it is important to the field of petrophysics and geology, so that the results are analyzed in a way beyond common sense. (Yarus et al., 2006)

II.3 ANALYSIS OF UNCERTAINTIES

To evaluate the uncertainty space, i.e., the joint probability of several points in the space exceed the same cutoff value, are used Geostatistical simulation models, with which, it intends to generate a set of spatial images of the phenomenon, in which the statistical spatial variability (histogram and variogram or spatial covariance), quantified by the samples are played. These images, with equal representation of the problem space, are called equiprobable images (Soares, 2006). The aim of these simulation models used to calculate the uncertainty space is to generate a set of images representative of the phenomenon and equiprobable space, as they are played the same statistical spatial variability quantified by samples or observations (histogram and variogram or spatial covariance) (Soares, 2006).

III. BASICS OF THE VARIABLES UNDER STUDY

For this work were provided data from 10 wells in total and of the acoustic impedance cube that serves as secondary and complementary information for the characterization and study of these wells. Among the data provided information on the wells contained the following variables:

- Acoustic impedance.
- Permeability.
- Porosity

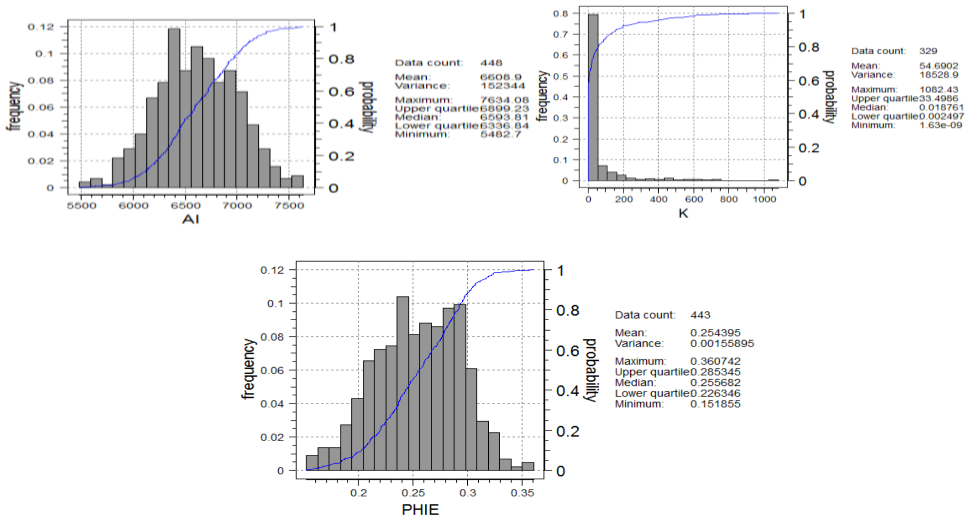

Figure 1 – Histograms of variables and respective cumulative probability function

IV. WORKING METHOD

A summary of the working method used is described below and shown in the figure below. However, when necessary, details on the methods used will be discussed during the report.

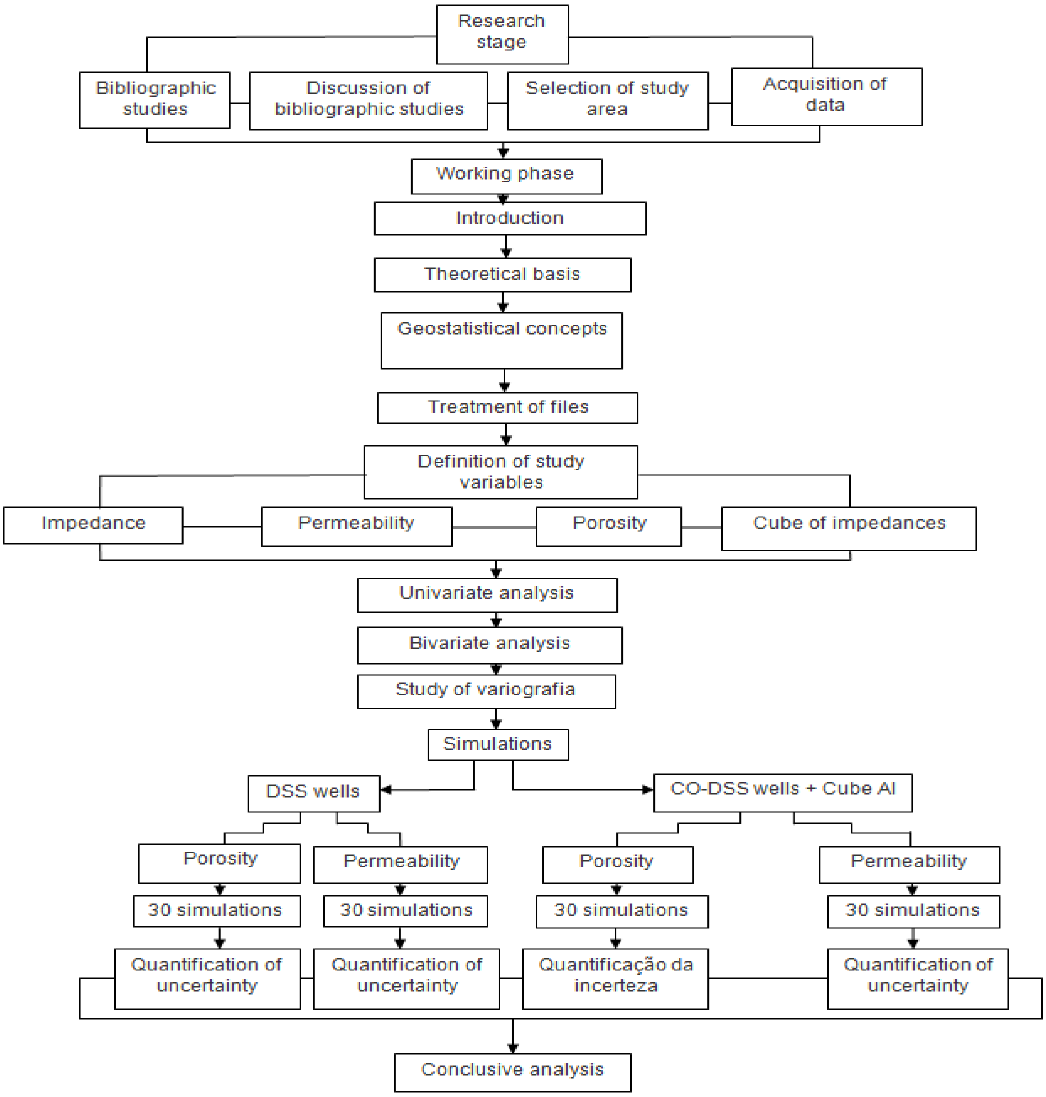

Figure 2- Organization chart of the working phases(Elaboração propria)

V. RESULTS

V.1. Variance of DSS of permeability

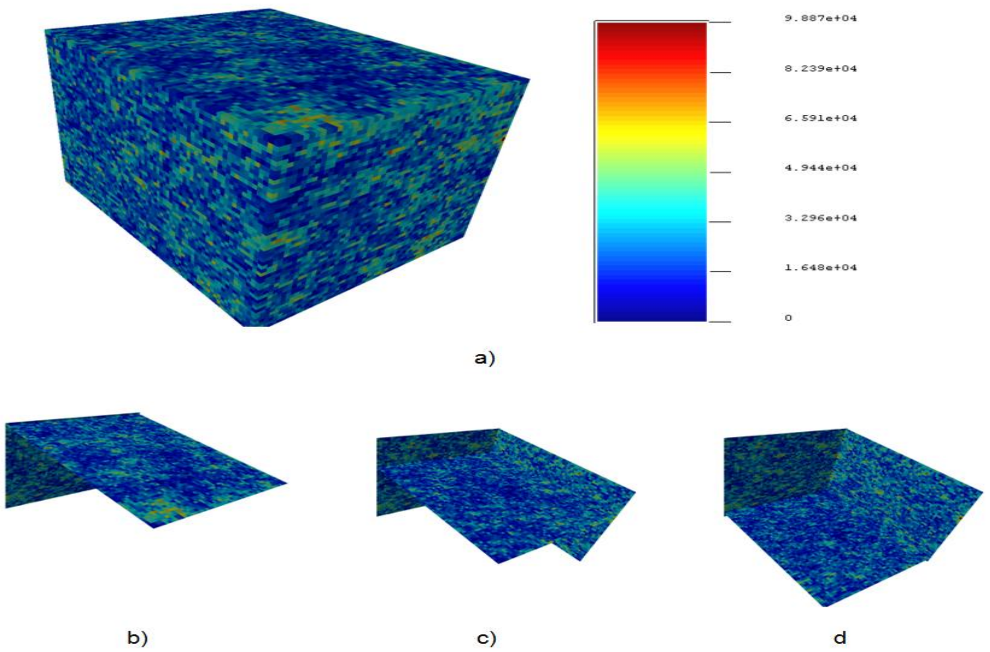

Figure 3 - Variance of the 30 simulations of permeability (Sgems)

V.2. Variance of CODSS permeability

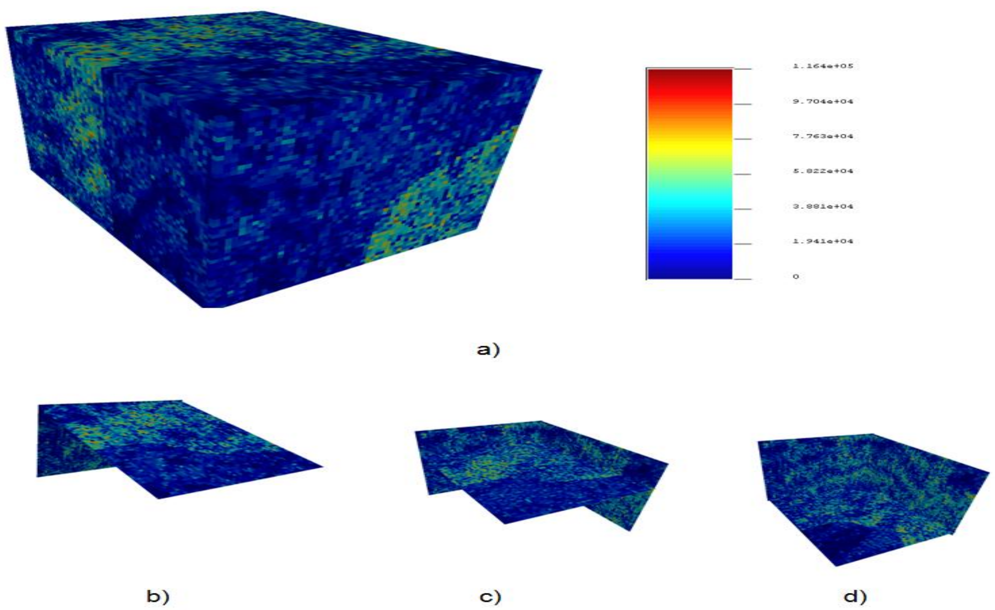

Figure 4 - Variance of the 30 Co-simulations of permeability

V.3. Variance of DSS of porosity

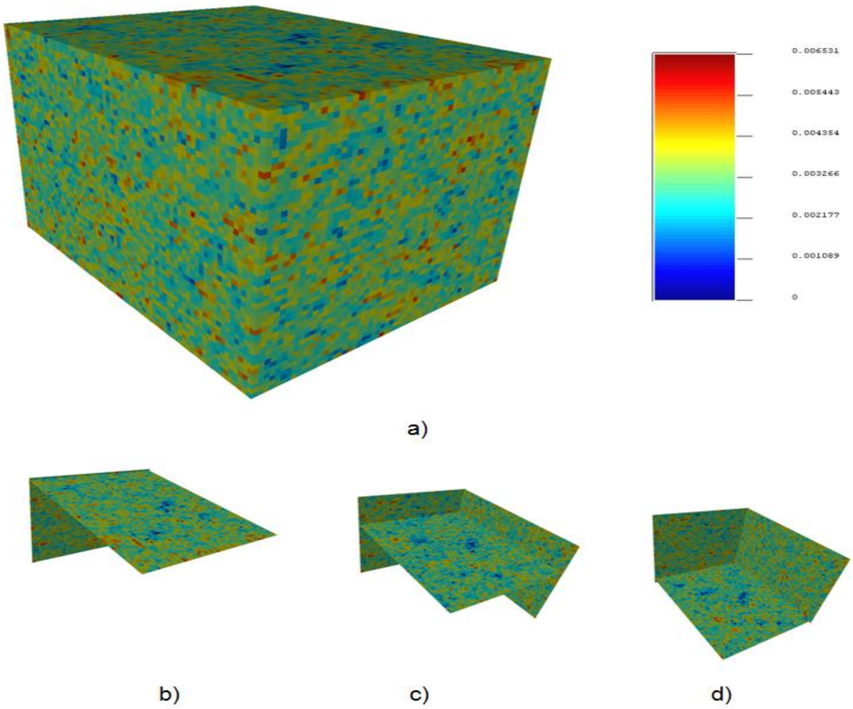

Figure 5 - Variance of 30 simulations of porosity

V.4. Variance of CODSS porosity

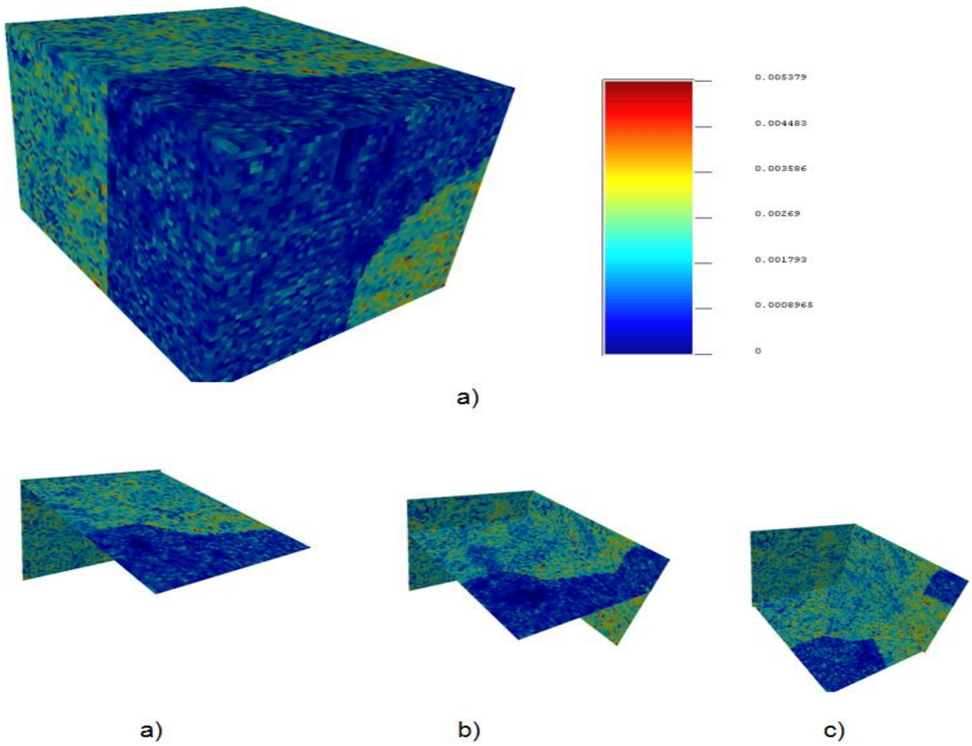

Figure 6 - Variance of the 30 Co-simulations of porosity

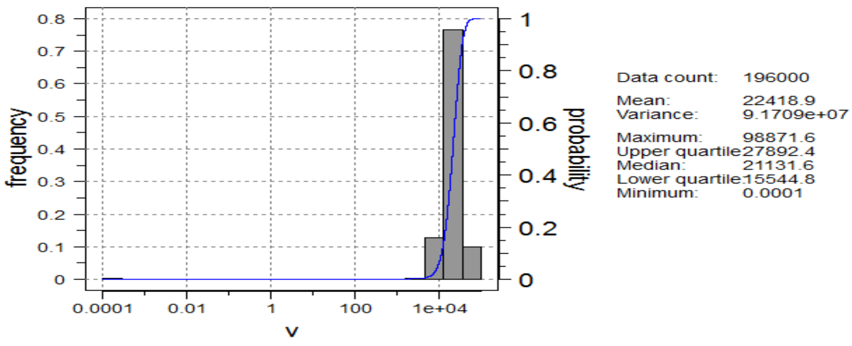

Figure 7 - Histogram of the variance of the 30 SSD of permeability

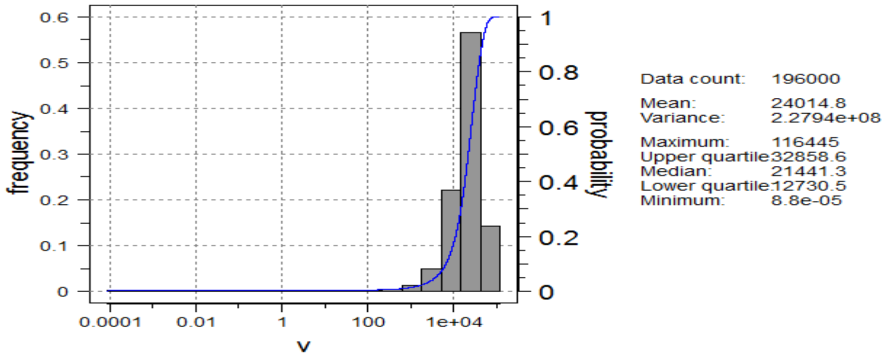

Figure 8 – Histogram of the variance of the 30 CoSSD of permeability

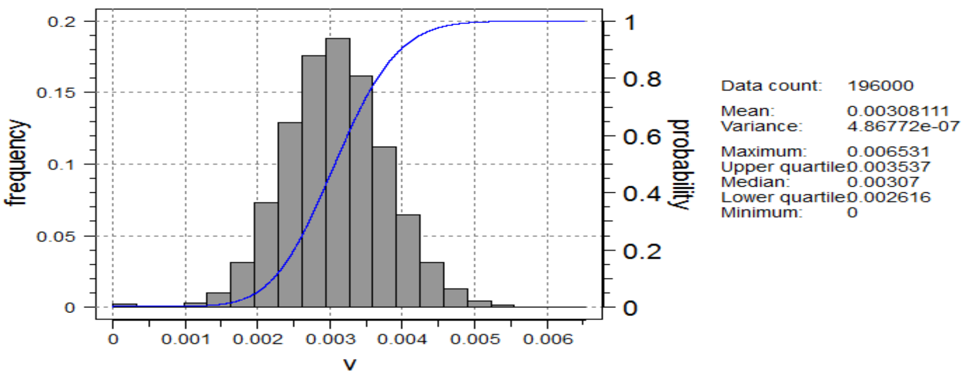

Figure 9 – Histogram of the variance of the 30 SSD of porosity

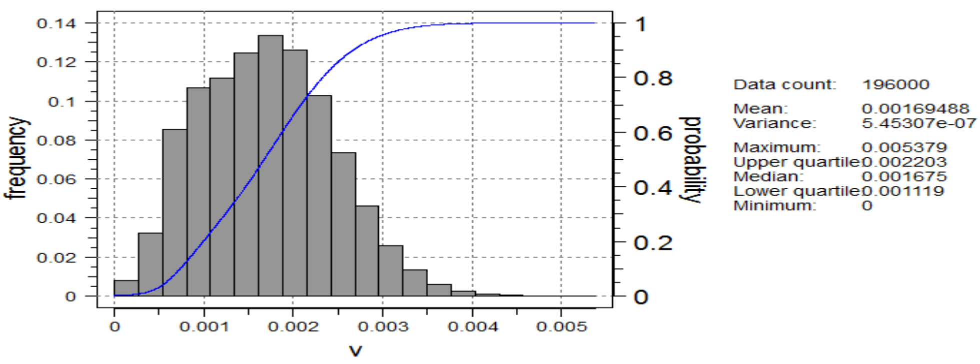

Figure 10 - Histogram of the variance of the 30 CoSSD of porosity

VI. CONCLUSIVE ANALYSIS

In this paper was tested two methods of simulation for an oil field in order to know which of the two methods best quantifies the uncertainty of the data in question, for this, was performed a direct sequential simulation, it was considered only the information from the wells, that is, the acoustic impedance data, permeability and porosity. And the direct sequential co-simulation in which was considered the information of wells and acoustic impedance cube as secondary image.

After the achievement of the 30 simulations for each simulation method was made the calculation of means and variances, considering that in each of them were treated the variables permeability and porosity, it was found that the direct sequential simulation performed only with information from wells, has more uncertainty than the results of direct sequential co-simulation.

At the achievements obtained as a result of direct sequential simulation was possible to observe that there were areas of high variability for porosity and on a smaller scale for permeability. However, the achievements that were obtained by direct sequential co-simulation, and for which was used the image impedances of the cube as secondary information, showed less variability and less uncertainty than the previous method.

In this sense, the simulation made, in which was take into account the information of the cube as secondary image turns out to be the best method to quantify the uncertainty of the data from this case study, because it has much more information available and somehow more conditioned, which makes the level of search much lower. In general, the more secondary information is possible to condition the simulation of variables and depending on the correlation that may exist between this information and information of the secondary variables, often turns out to be a good method for the analysis or quantification of the uncertainty of certain property.

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