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Petrophysical database of Uganda

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A B S T R A C T

The petrophysical database of Uganda contains data on ca. 5800 rock samples collected and analyzed during 2009–2012 in international geological and geophysical projects covering the main part of the land area of Uganda. The parameters included are the susceptibilities and densities of all available field samples. Susceptibilities were measured from the samples from three directions. Using these parameters, we also calculated the ratios of susceptibility maxima/minima reflecting direction homogeneity of magnetic minerals, and estimated the iron content of paramagnetic samples and the magnetite content of ferrimagnetic samples.

Statistical and visual analysis of the petrophysical data of Uganda demonstrated their wide variation, thus emphasizing their importance in analyzing the bedrock variations in three dimensions. Using the density–susceptibility diagram, the data can be classified into six main groups: 1. A low density and susceptibility group, consisting of sedimentary and altered rocks. 2. Low-susceptibility, felsic rocks (e.g. quartzites and metasandstones). 3. Paramagnetic, felsic rocks (e.g. granites). 4. Ferrimagnetic, magnetite-containing felsic rocks (e.g. granites). 5. Paramagnetic mafic rocks (e.g. amphibolites and dolerites). 6. Ferrimagnetic, mafic rocks containing magnetite and high-density mafic minerals (mainly dolerites).

Moreover, analysis revealed that the parameter distributions of even a single rock type (e.g. granites) can be very variable, forming separate clusters. This demonstrates that the simple calculation of density or susceptibility averages of rock types can be highly erratic. For example, the average can lie between two groups, where only few, if any, samples exist. Therefore, estimation of the representative density and susceptibility must be visually verified from these diagrams. The areal distribution of parameters and their calculated derivatives generally correlate well with the regional distribution of lithological and geophysical blocks. However, there are also several areas where, for instance, the low susceptibility of samples correlates poorly with high magnetic airborne anomaly data. This refers to high remanence, or the anomalies may be due to sources covered by a less magnetic sedimentary cover.

The petrophysical database will be a necessity when modeling the bedrock of Uganda in three dimensions at any scale. The lithological and petrophysical databases, as well as the samples collected, will further serve as a very valuable and important basis of and provide tools for future studies on the bedrock cover of Uganda. They can be used, for example, for bedrock mapping, prospecting of valuable mineralizations, dimension stones and for environmental studies. The samples could also serve as basis for establishing a lithogeochemical database of Uganda. It is clear that the data and samples are already commercially valuable for numerous prospecting companies working in Uganda. Thus, it is important that the samples and databases are carefully, safely and permanently archived and stored for future use.

Contents

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1. Introduction

During 2008–2012, the geology of most of Uganda was studied within the framework of the Sustainable Management of Mineral Resources Project (SMMRP). During the project, comprehensive airborne magnetic and radiometric surveys were flown over ca. 80% of the country. Geological, petrophysical and geochemical sampling, geological field studies and detailed geophysical field profiles were undertaken in selected sub-areas. The project was headed by the Finnish Geological Survey (GTK), together with the Department of Geological Survey and Mines of Uganda (DGSM). It was funded by the Government of Uganda, the Nordic Development Fund (NDF), the World Bank (IDA) and the African Development Bank (ADB). During the project, ca. 5700 bedrock samples were collected by field geologists covering most of the land areas of Uganda (Fig. 1). The sample locations were defined by GPS and their base rock characteristics were documented by camera and written notes.

From the map in Fig. 1, the relatively large areal variations in sampling densities should be noted, which were mainly due to the rough terrain, swamps, lakes and rivers. Thus, areal variations in and numbers of samples of different rock types do not necessarily reflect the variations in the underlying bedrock. Moreover, the rock type names were assigned by field geologists based on visual evaluation of the sample mineral composition, and can thus sometimes be erratic. For example, granites with densities above ca. 2800 kg/m^3 (Fig. 8) must be taken with care, or must be studied more closely, because of possible high-density mineralizations.

The samples, maps, reports and detailed geological databases are archived on the properties of the DGSM, Entebbe. The samples are stored in separate boxes, each containing 20–50 samples. The petrophysics sub-project has measured densities and susceptibilities of all available field samples using the petrophysical 'field laboratory' shown in Fig. 2. The densities were measured using a small weighing scale (max 10 kg, accuracy ca. 1 g). The density was evaluated by measuring weight in air (Wa [g]) and water (Ww [g]), from which density is calculated by: D [kg/m^3] = 1000 $*$ Wa/(Wa − Ww). The susceptibilities were measured using an SM-20 hand-held susceptibility meter (ZHinstruments, 2002). The sensitivity of the susceptibility meter is ca. 1×10^{-6} SI units, operating frequency 11 kHz, measurement time is less than 5 s, display is 4 digits LCD, pick-up coil diameter 50 mm, and operating temperature is from ca. −10 °C to +50 °C. The susceptibility of each sample was measured from three sample surfaces approximating *x*- *y*- and *z*-directions, thus reflecting the effect of remanent magnetization of the samples. Moreover, densities and susceptibilities of five standards were measured each time a new sample box was started.

It should be noted that African petrophysical laboratories exist, for instance, in South Africa (http://www.sgs.co.za/en/Oil-Gas/Upstream/Reservoir-and-Field-Solutions/Specialized-Studies/Petrophysics-and-Geology.aspx) and Tanzania (http://www.gst.go.tz/add/service_laboratry_Petrophysical.html). However, it appears that the Uganda petrophysical database described here is the first national African database systematically covering the main part of the country's land areas.

2. Structure of the database

The database consists of an Excel file that is a combination of the primary petrophysical working data files linked with information from field data observations by geologists. In the database, the contents of various sheets and columns are explained by corresponding notes. The columns of the database provide, for example, coordinates, rock types, weights in water and air, sample volumes, densities and susceptibilities. Moreover, the database contains derivatives calculated using combinations of susceptibilities and densities described below in more detail.

3. Standards

Susceptibilities and densities of five standards selected from GTK petrophysical laboratory samples (ST1–ST5) were measured each time the measurement of a new sample group (i.e. sample