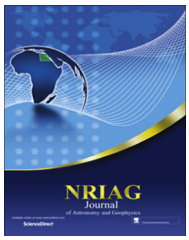
NRIAG Journal of Astronomy and Geophysics (2015) 4, 154–162

National Research Institute of Astronomy and Geophysics

NRIAG Journal of Astronomy and Geophysics

www.elsevier.com/locate/nrjag



Magnetic and gravity data analysis of Rahat Volcanic Field, El-Madinah city, Saudi Arabia

Essam Aboud [a,*], Nabil El-Masry [a], Atef Qaddah [a], Faisal Alqahtani [b], Mohammed R.H. Moufti [a]

[a] *Geohazards Research Center, King Abdulaziz University, P.O. Box 80206, Jeddah 21589, Saudi Arabia*
[b] *Faculty of Earth Science, King Abdulaziz University, P.O. Box 80206, Jeddah 21589, Saudi Arabia*

Received 11 September 2014; revised 28 April 2015; accepted 29 June 2015
Available online 13 July 2015

KEYWORDS

Rahat;
Madinah;
Gravity;
Magnetic;
Saudi Arabia

Abstract The Rahat volcanic field represents one of the widely distributed Cenozoic volcanic fields across the western regions of the Arabian Peninsula. Its human significance stems from the fact that its northern fringes, where the historical eruption of 1256 A.D. took place, are very close to the holy city of Al-Madinah Al-Monawarah.

In the present work, we analyzed aeromagnetic data from the northern part of Rahat volcanic field as well as carried out a ground gravity survey. A joint interpretation and inversion of gravity and magnetic data were used to estimate the thickness of the lava flows, delineate the subsurface structures of the study area, and estimate the depth to basement using various geophysical methods, such as Tilt Derivative, Euler Deconvolution and 2D modeling inversion.

Results indicated that the thickness of the lava flows in the study area ranges between 100 m (above Sea Level) at the eastern and western boundaries of Rahat Volcanic field and getting deeper at the middle as 300–500 m. It also showed that, major structural trend is in the NW direction (Red Sea trend) with some minor trends in EW direction.

1. Introduction

Harrat Rahat (Harrat = Volcanic field) is one of the Cenozoic lava fields in Saudi Arabia. Volcanic field in Saudi Arabia extends across the western regions of the Arabian Peninsula from Yemen in the south to the Levant in the north. They markedly define different phases of magmatic activity that took place during the 30 million years history of the Red Sea–Gulf of Aden rift system (Camp et al., 1987; Camp and Roobol, 1989, 1991; Bosworth et al., 2005). The Rahat Volcanic Field (RVF) occupies a 50 km wide plateau that

* Corresponding author at: National Research Institute of Astronomy and Geophysics, NRIAG, Cairo, Egypt.
E-mail address: eaboudishish@kau.edu.sa (E. Aboud).

Peer review under responsibility of National Research Institute of Astronomy and Geophysics.

http://dx.doi.org/10.1016/j.nrjag.2015.06.006
2090-9977 © 2015 Production and hosting by Elsevier B.V. on behalf of National Research Institute of Astronomy and Geophysics.

extends from north to south for almost 300 km between the Hejaz coastal range on the west and the high plains of Najd on the east (Durozoy, 1970; Berthier et al., 1981) as shown in Fig. 1. It has an approximate volume of 2000 km^3 (Camp et al., 1987; Camp and Roobol, 1989, 1991) and an estimated average thickness of about 150 m south of latitude 24° N (Blank and Sadek, 1983). The most recent eruption of 1256 AD, which lasted for 52 days, extruded 0.5 km^3 of alkali-olivine basalt from a 2.25 km long fissure and produced 6 scoria cones and a 23 km-long lava flow that came to within 8 km from Al-Madinah city (Camp et al., 1987, 1989; Ambraseys et al., 1994).

Two major hazard events were documented and located within the study area; eruption of 1256 AD and the earthquake swarm in 1999 (El Difrawy et al., 2013). In the current study, we used gravity and magnetic data to evaluate the above mentioned hazards.

The objectives of the current work are to image the subsurface structure, estimate the average thickness of the overlying Cenozoic lava flows, and estimate the depth to the basement underneath the lava flows. Therefore, a ground gravity survey was carried out in the northern part of RVF using a CG5 gravimeter and a differential GPS instrument. Gravity data were used in parallel with the available aeromagnetic data over RVF and the surrounding Precambrian Arabian shield reported by the Bureau de Recherches Geologiques et Minieres (BRGM) and the Saudi Geological Survey (SGS), (BRGM, 1966.

In that regard, we used Euler deconvolution method to estimate the depth to the basement rocks from magnetic data, The Tilt Derivative (TDR) method to trace the major lineation in the area, and finally, 2D joint inversion of gravity and magnetic data to map the lava flows and estimate its thickness.

2. Geological setting

The northern terrains of RVF (Fig. 1), referred to as Harrat Al-Madinah (Moufti, 1985), are largely constructed of monogenetic, Strombolian-style basaltic volcanoes and basaltic lava flows, which extruded onto the Precambrian basement rocks of the Arabian Shield through NNW-trending *en echelon*-vent zones (Moufti et al., 2010). The basalts range from olivine transitional basalt and alkali olivine basalt to hawaiite, whereas the associated evolved rocks of mugearite, benmoreite, and trachyte occur mainly as domes and tuff cones as well as lava flows (Moufti et al., 2010, 2012). Harrat Al-Madinah basalts were further divided into the lower Madinah basalt and the upper Madinah basalt (Camp et al., 1987; Camp and Roobol, 1989, 1991). The upper Madinah basalts comprised three flow units, namely Qm1 (~1.7–1.2 Ma), Qm2 (~1.2–0.9 Ma), and Qm3 (~0.9–0.6 Ma), whereas the upper Madinah basalt included four flow units, namely Qm4 (~0.6–0.3 Ma), Qm5 (~0.3 Ma–4500 BP), Qm6 (~4500–1500 BP), and Qm7 (~1500 BP –1256 AD, Fig. 2), (Camp et al., 1987; Camp and Roobol, 1989, 1991).

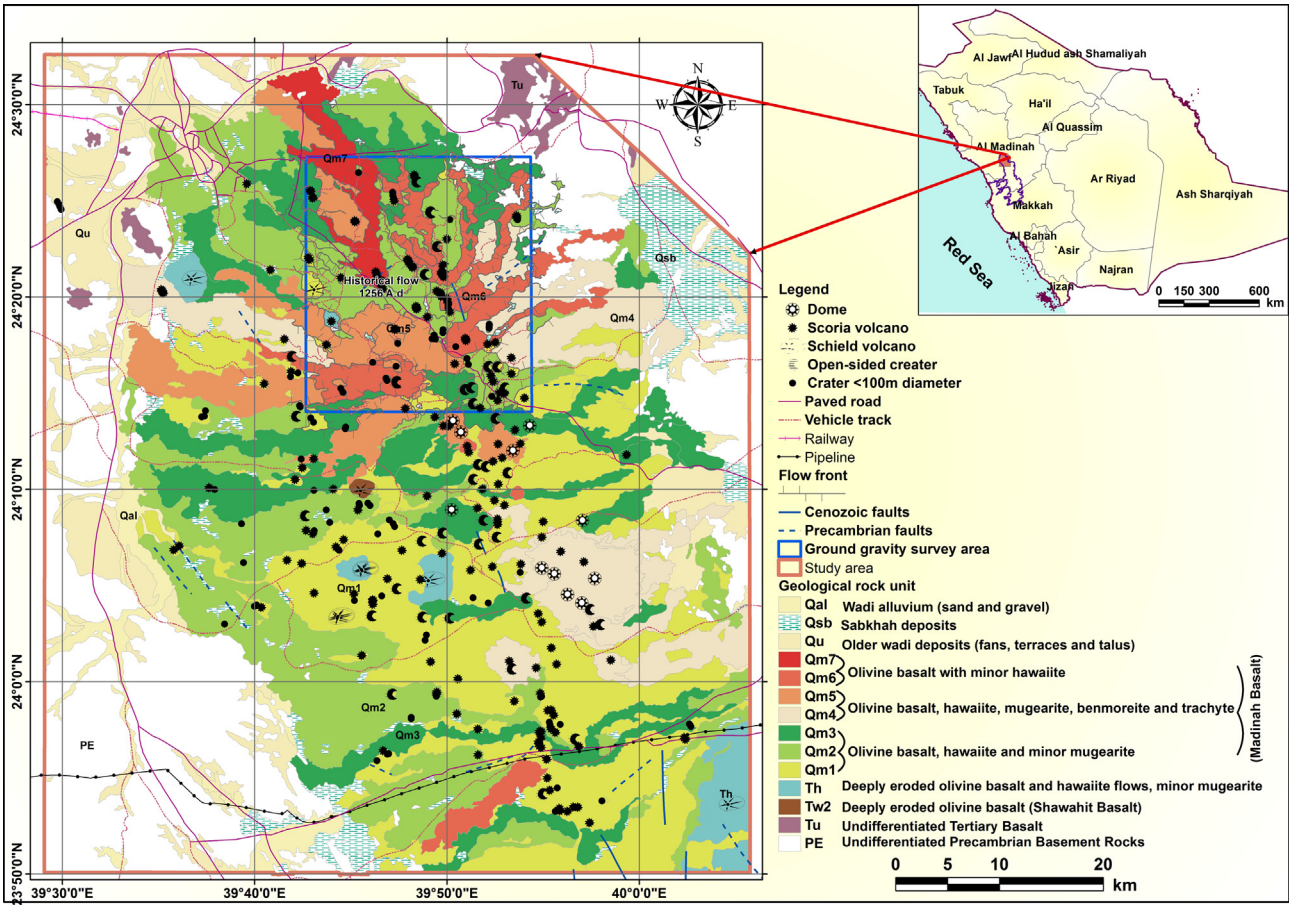


Figure 1 Geologic map of northern Rahat volcanic field (modified after Camp and Roobol, 1991).