Annals of Arid Zone 29 (3) : 215-219, 1990

CONTRIBUTION TO GEOLOGY OF THE MAKKAH AREA, SAUDI ARABIA

AHMED A. ALMOHANDIS

Department of Geology, College of Science,
King Saud University, Riyadh, Saudi Arabia

Makkah is the holiest of Muslim cities. It is located in the sirat Mountains inland from the Red Sea Coast of Saudi Arabia. It is situated at an elevation of 277 metres above sea level in the dry beds of the Wadi Ibrahim and several of its short tributaries (Abdo 1974). There is less than five inches of rainfall during the year, mainly in the winter months. Temperature is high throughout the year and in summer it may reach to 45°C. Vegetation and animal life are scarce and consist of species that can withstand high degree of aridity and heat. The Makkah city centres upon the Al-Haram mosque and the sacred well of Zamzam is located inside the mosque.

The purpose of this paper was to investigate the geological features of the Makkah area, especially around the holy mosque. In addition, chemical study of Zamzam water was also undertaken.

The geological features of the Makkah area were investigated during two field trips in 1985. A geological map was constructed from the general map of Brown (1972). Rock types in the Makkah area, especially around the holy mosque and in the city were identified. Representative rock samples were collected and thin sections were prepared for petrographic examination. Three representative samples of Zamzam ground water were collected and analysed for chloride by the mercuric nitrate methods, sulphate and bicarbonate by the turbidimetric method, calcium and magnesium by atomic absorption and sodium and potassium by flame photometry.

The Makkah area is part of the Arabian Shield (Brown and Jackson 1960) which is regarded as a continuation of the adjacent African Shield and is now separated from it by the Red Sea rift. Most rocks around the Makkah city are plutonic igneous rocks. The dominant type of these are granitic rocks, and range in composition from quartz diorites through tonalite (Skiba 1980). Fig. 1 shows the general geology of the Makkah area (Brown 1972; Brown et al. 1963). The plutonic rocks are represented in the map as pretectonic granitoid rocks. Several plutons of quartz bearing diorites crop out south and east of Makkah and several hills of dioritic composition occur just north of Wadi Fatima. The quartz-bearing diorites exposed east and south of Makkah show a well developed planar fabric.

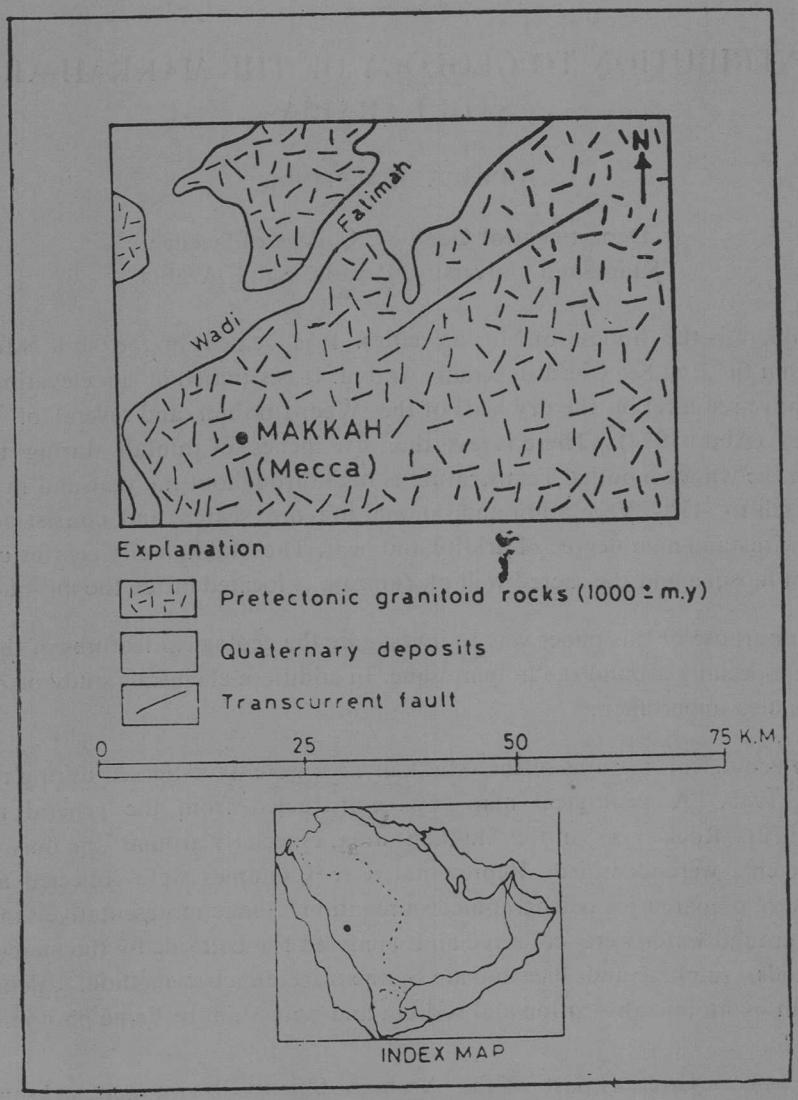

Fig. 1. Generalized geological map of the Makkah area, Saudi Arabia (Modified after Brown 1972).

Zamzam well receives its water from the precambrian rocks through three sets of fractures which are extending from Kaabah, Safa and Marwah directions, intersecting at the well (Basalamah 1980). The basement rocks are covered with silt, sand and gravel of variable thickness derived from adjacent igneous rocks. The upper part of the well is mainly alluvial deposits. The aquifer is unconfined, the water bearing formations are the alluvial deposits and fracture zones in the igneous rocks.

Modal composition of four representative rock samples are given in Table 1. All samples fall in the diorite field (Streckeisen 1973). Megascopically the quartz diorite samples are medium-grained, with greenish grey colour, while the hornblende-augite diorite is dark grey and fine to medium-grained.

Table 1. Modal analysis of the Makkah plutonic rocks, Saudi Arabia

Minerals	Sample No.			
%	MK-70	MK-71	MK-72	MK-73
Plagioclase	61	60	55	62
Hornblende	14	15	25	15
Augite	—	—	15	—
Quartz	10	10	—	10
Biotite	12	13	03	12
Epidote	03	02	traces	01
Sphene	—	traces	—	—
Calcite	—	traces	—	traces
Opaques	traces	traces	02	traces
Rock Name	Qtz-diorite	Qtz-diorite	Hb-Augite diorite	Qtz diorite

In thin section, the quartz diorite is medium-grained, holocrystalline showing equigranular texture. The rock is dominantly composed of subhedral plagioclase (andesine) with subordinate amounts of brownish green hornblende and interstitial anhedral quartz. The plagioclase is commonly saussuritized in the cores of the larger crystals. Biotite occurs as interlocking aggregates. Calcite, sphene, iron oxides and pyrite occur only in traces and as secondary minerals.

Under microscope, the hornblende diorite shows an equigranular texture. It is dominantly composed of plagioclase (andesine), with subordinate amounts of greenish brown hornblende and pale green augite. Hornblende grains show poikilitic character enclosing small grains of plagioclase. Brown biotite occurs also as an accessory mineral. Epidote is present in trace amounts as alteration products of plagioclase. Magnetite is the opaque mineral in this rock.

The results of the analyses of Zamzam water are shown in Table 2. Zamzam water is colourless, odourless and salty in teste. The average pH value (7.5) indicates that the Zamzam water is slightly alkaline, and the average T.D.S. value of 1488 indicates that it is medium hard water. All cations and anions of the Zamzam water except sodium are within the world health standards (WHO 1971). Naeem et al. (1983) showed that the concentrations of more than 30 elements present in the Zamzam water are well within the permissible limits. However, the composition of the Zamzam water is affected by the aridity which results in an increased salt concentration in the recharge water by evaporation.

Table 2. Chemical composition of Zamzam water Makkah (mg L^{-1})

Sample No.	pH	T.D.S.	K^+	Na^+	Mg^{++}	Ca^{++}	Cl^-	SO_4^-	HCO_3^-
ZM-70	7.5	1491	12	332	54	104	360	290	395
ZM-71	7.6	1485	14	331	57	101	362	286	397
ZM-72	7.5	1489	14	333	52	101	359	285	393
World Maximum Permissible Limit (WHO, 1971)	—	1500	—	—	150	200	600	400	—

The abundance of granitic rocks in the Makkah area suggests that the magma which produced these rocks probably came through partial melting of the lower parts of continental crust. The partial melting may be accompanied by some mixing of crustal material and andesitic magma derived from subducted material (Greenwood and Brown 1973; Nasseef and Gass 1977; Marzouki and Fyfe 1977).

ACKNOWLEDGEMENT

Thanks are due to the Research Centre, College of Pharmacy, King Saud University for water analysis facilities.

This research (Geo/1403/39) was supported by the Research Centre, College of Science, King Saud University, Riyadh, Saudi Arabia.

REFERENCES

Abdo, A. 1974. Mecca (Makkah), Encyclopaedia Britannica Vol. 11, Chicago, U.S.A., P. 753-755.

Basalamah. H.A. 1980. Construction history of the Holy Mosque of Makkah, Saudi Arabia. The Saudi Arabian Book series In. Tihama, Jiddah, 3rd. edition (in Arabic), 250 pp.

Brown, G.F. 1972. Tectonic map of the Arabian Peninsula. Saudi Arabian Dir. Gen. Miner. Resour., Map AP-2, scale 1 : 4,000,000.

Brown, G.F. and Jackson, R.O. 1960. The Arabian Shield: International Geological Congress 21 st., Copenhagen, 1960, Proceedings, pt. 9, p. 67-77.

Brown, G.F., Jackson R.O., Bogul R.O. and Maclean, W.H. 1963. Geologic map of the southern Hijaz Quadrangle, Kingdom of Saudi Arabia : U.S. Geological Survey Miscellaneous Geologic investigation Map I- 210-A, scale 1:500,000.

Greenwood, W.R. and Brown, G.F. 1973. Petrology and chemical analysis of selected plutonic rocks from the Arabian Shield, Kingdom of Saudi Arabia. Saudi Arabian Dir. Gen. Mineral Resources, Bull 9, 9 pp.

Marzouki, F. and Fyfe, W.S. 1977. Pan-African plates. additional evidence from igneous events in Saudi Arabia. Contr. Mineral. Petrol., 60 : 219-224.

Naeem, A., Alsanussi, M. and Almohandis, A. 1983. Multielement and hydrochemical study of holy Zamzam water. Journal of the new England Water Works Association Mass. 02026, U.S.A., Vol. 97 : 156-169.

Nasseef, A.O. and Gass, I.G. 1977. Granitic and metamorphic rocks of the Taif area, Western Saudi Arabia. Geol. Soc. Amer. Bull. 88 : 1721-1730.

Skiba, W.J. 1980. The form and evolution of late precambrian plutonic rocks in the Jiddah-Rabigh-Wadi Al-Qahah area. Saudi Arabia. In: Evolution and Mineralization of the Arabian-Nubian Shield (Convenor : A.M. Alshanti) Bull. Inst. Appl. Geol. King Abdulaziz Univ. (Jiddah) 3, (Vol.3) p. 105-12 Pergamon Press, Oxford.

Streckeisen. A.L. 1973. Plutonic and nomenclature recommended by the I.U.G.S. submission on the systematics of igneous rocks. Geotimes 18: 20-30.

World Health Organization (WHO) 1971. International standards for drinking water, 3rd Ed., Geneva, Switzerland, 70 pp.