Ain Shams University
Faculty of Science
Geology Department

Geochemical characteristics of stream sediments and water resources of El-Allouga area and its vicinity, southwestern Sinai: Environmental implications

By

Randa Ramadan Said El Sayed

B.Sc. in Geology, Ain Shams University (2013)

A Thesis

Submitted to the Geology department

Faculty of Science, Ain Shams University

In Partial Fulfillment of

Master Degree in Science "Geology"

2018

Ain Shams University
Faculty of Science
Geology Department

Geochemical characteristics of stream sediments and water resources of El-Allouga area and its vicinity, southwestern Sinai: Environmental implications.

By

Randa Ramadan Said El Sayed

B.Sc. in Geology, Ain Shams University (2013)

A Thesis

Submitted for Partial Fulfillment of

Master Degree of Science in Geology.

Ain Shams University.

Prof. Yehia H. Dawood
Professor of Mineralogy and geochemistry, Geology Department, Ain Shams University.

Prof. Mohamed Mokhtar Yehia
Professor of Hydrogeochemistry, Central Laboratory for Environmental Quality Monitoring (CLEQM), National Water Research Center, El Kanater.

Dr. Ahmed Gad Abd El Wahed
Lecturer of Environmental Geology, Geology Department, Ain Shams University

2018

APPROVAL SHEET

Title of the M.Sc. Thesis

Geochemical characteristics of stream sediments and water resources of El-Allouga area and its vicinity, southwestern Sinai: Environmental implications.

Candidate Name

Randa Ramadan Said El Sayed

Submitted to

The Department of Geology Faculty of Science, Ain Shams University

This thesis has been approved for submission by the supervisors

Prof. Yehia H. Dawood	*Ain Shams University*
Prof. Mohamed Mokhtar Yehia	*National Water Research Center, El Kanater*
Dr. Ahmed Gad Abd El Wahed	*Ain Shams University*

ABSTRACT

Mineralogy, geochemistry and radioactivity of the stream sediments and water resources in southwestern Sinai were investigated using collaborative techniques. Four wadis were selected for the present study; namely Wadi Nasieb, Wadi Baba, Wadi El-Seih and Wadi El-Sahu. These wadis are located close to the known occurrences of uranium, cupper, manganese and rare earth bearing mineralizations. The study area is covered by rock exposures ranging in age from Precambrian to Permo-Triassic. Forty nine samples were collected from the studied areas including sediments, groundwater and country rocks of water wells.

Textural and mineralogical characteristics of the stream sediments revealed that the clay minerals are present mostly as kaolinite and illite. The heavy minerals are dominated by opaques, pyroxenes, amphiboles, zircon, tourmaline, rutile, epidote, kyanite, sillimanite, monazite, staurolite, barite, xenotime and apatite. Autunite and Goyazite are reported for the first time in these sediments. Autunite forms encrustation on colloidal iron oxide grains whereas goyazite is found as prismatic grains. The two minerals show considerable contents of Rare Earth Elements, mainly Ce, La, Pr, Sm and Nd. Texturally, the unimodal grain size distribution, the subangular to subrounded grains and the poorly sorting class denotes short transportation distance from one source area. Mineralogically, the low ZTR index indicates a mineralogical immature to sub-mature sediments. The prismatic ultrastable zircon, tourmaline and rutile and the dominance of unaltered amphibole and pyroxene grains as well as absence of chlorite indicate that the source rocks are mainly the nearby exposed basement units. The presence of uranyl minerals and rare earth bearing phosphate minerals in these sediments reflect a contribution from the Palaeozoic sedimentary successions.

The stream sediments of the study area is characterized by cations pattern as $Na^{+}< Ca^{2+}< K^{+}< Mg^{2+}$ and anions as $Cl^{-}< HCO_3^{-}< NO_3^{-}$. Strong +ve correlations between these elements indicate the occurrence of major salts (sodium chloride and calcium, magnesium carbonate). The heavy metals are found mainly in the stream sediments in the accessory minerals such as galena, pyrite, ilmenite, barite and pyrolusite and not adsorbed on clays or organic matters. Although the enrichment factors of some metals such as Cu, Zn and Pb show very high to extremely severe enrichment, but compared to the maximum allowable limit of heavy metals in soil, the stream sediments in the study area are considered not polluted with respect to toxic heavy metals.

For groundwater, the cations pattern is $Na^{+}> Ca^{2+}> Mg^{2+}> K^{+}$, and the anions is $Cl^{-}> SO_4^{2-}> HCO_3^{-}> NO_3^{-}> F^{-}> NO_2^{-}$. Most of the heavy metals in groundwater samples are under maximum contamination level except Al and Mn. The excess of alkaline earth elements (Ca and Mg) over HCO_3 in groundwater indicates additional sources of Ca and Mg, most probably supplied by silicate weathering. The concentration of some elements in groundwater such as Cr, Cu and Mg reflect the effect of water-rock interaction in the leaching of these elements.The major ions (Na, Mg, Ca, Cl, and HCO_3) are relatively enriched in the groundwater reflecting their relative high mobility, while heavy metals e.g. Cu, Zn, Mn, Cr, Ba and Ni show more affinity for the country rocks.

Most of stream sediments from the studied wadis have eU concentrations more than the average of U in the earth's crust. Wadi El Sahu stream sediments display the highest contents of eU, eTh and ^{40}K compared to the other wadis indicating derivation from the nearby granitic rocks to this wadi. Unlike other heavy metals, the significant correlations between eU, clay contents and organic matters, reflect the adsorption of U to the surface of clays and organic matters. The association of eU and Fe indicates precipitation of uranyl minerals on iron oxide grains in the stream sediments. This association is also observed in the source rocks.

All groundwater samples exceed the Maximum Contamination Level (MCL) of groundwater uranium (30 ppb). So, the available water resources in the study area are considered unsafe for human consumption and irrigation. The lack of correspondence of uranium concentrations in the country rocks and associated groundwater reflects the high mobility of uranium and indicates that there does not exist a simple rock/water equilibration.

Uranium distribution in the groundwater is largely dependent on the high solubility and mobility of this element and on the salinity of the groundwater. Both surface and subsurface waters in the study area have $^{234}U/^{238}U$ activity ratios with obvious deviations from secular equilibrium. The isotope data indicates no mixing relations between water of different wells. The uranium isotopic data support that U ore body could locally be forming within rock aquifer at El-Allouga area ($^{234}U/^{238}U$ activity ratio at El-Allouga drilled well = 14). This very high activity ratio most probably reflects uranium deposition from water.

Dedicated to

My father's soul

My mother

&

My lovely husband

ACKNOWLEDGEMENTS

First of all, praise is due to almighty ALLAH for his compassion and mercifulness that allowed me finish this work

The author would like to express her deep appreciation to the National Water Research Center, El Kanater and Nuclear materials authority for providing the facilities during the progress of this research work.

I am greatly indebted and deeply grateful to the supervisors of this thesis: ***Prof. Yehia H. Dawood*** *(Geology department, Faculty of science, Ain Shams University),* ***Prof. Mohamed Mokhtar Yehia*** *(National Water Research Center, El Kanater) and* ***Dr. Ahmed Gad Abd El Wahed*** *(Geology department, Faculty of science, Ain Shams University for their immense knowledge, close supervision, sincere guidance, fruitful discussions and a continuous support*

My gratitude also to ***Prof. Ibrahim E. El Aassy,*** *geologist* ***Salama Bahr*** *and geologist* ***Amany Refaat*** *(Nuclear materials authority),* ***Prof. Adel Yehia, Prof. Ashraf R. Bagddady*** *and geologist* ***Yasmen Gamal*** *(Ain Shams University) for their assistance during the field work.*

Thanks are extended to ***Prof. Mohamed Galal El Feky*** *and* ***Dr. Nilly A. Kawady*** *(Nuclear materials authority),* ***Dr. Hassan Garramon*** *and my colleague* ***Mohamed mostafa*** *(Ain Shams University) and* ***Dr. Abdel Nasser Abu Zeid*** *(South Valley University).*

Finally I would like to express my hearty love and deepest gratitude to my family for their sympathetic feelings and care during this thesis

Contents