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***Provenance Analysis of Injana and Mukdadiya
Formations (Miocene/Pliocene) in Duhok Governorate,
Northern Iraq.***

A Thesis

*Submitted to the college of science, University of Baghdad as a partial
fulfillment of the requirements for the degree of Master of Science in
geology.*

By

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2010

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2018 A. C.

1440 A. H

Dedication

This work is dedicated

To my mother, the fountain of patience and tenderness, who led me through the valley of darkness with light of hope and support.

To my father soul, for his endless love, He has helped and encouraged me at every turn and pushed me to succeed. He has been a wonderful father.

To my dear uncle Khalefa, who stood by me and supported me.

To my loved brothers and sisters, candles my life and the source of my strength.

To my dearest wife, who patient and supporting me during the period of research.

To my precious daughters, the joy and flowers of my life, Maryam, Reham and Sidra.

To all people in my life who touch my heart.

Nazar Zaidan

Acknowledgement

First of all, I would like to thank and praise Allah for this blessing, kindness and supporting me during my life.

I would like to express my sincere thanks and gratitude to my supervisor, Professor Dr. Mazin Yousif Tamar-Agha for supporting me during the time of preparing my research. He has helped and encouraged me at every turn and pushed me to succeed. He has been a wonderful teacher.

I would like to express thank and gratitude for Dr. Hasan Kattoof Jasim for his valuable help.

I would like to thank Dr. Nnsen and Dr. Janan for their help in the field work.

I extend my sincere thanks and gratitude to my beloved family. my mother, my father, my brothers my sisters my wife and my daughters for their loving support and guidance as I worked to achieve my goals.

I would like to thank all my colleagues in Geology department of Baghdad University for their support assistance to me.

Nazar Zaidan

Abstract

This study deals with the petrography and heavy mineral analysis of Injana (Upper Fars) and Mukdadiya (Lower Bakhtiari) Formations in Zakho and Amadiya areas, Duhok Governorate.

A total of 58 samples are collected from Injana and Mukdadiya Formations representing: sandstone (21 samples from Injana Formation and 30 samples from Mukdadiya Formation), mudstone (5 samples from Mukdadiya Formation) and conglomerate (2 samples from Mukdadiya Formation). 37 samples of sandstone are thin sectioned for petrographic study (16 thin sections from Injana and 21 thin sections from Mukdadiya) and 40 sandstone samples are selected for heavy minerals study (17 samples from Injana and 23 samples from Mukdadiya). Also 5 samples of oriented mounts mudstone from Mukdadiya for X-ray diffraction and 2 samples of conglomerate from Mukdadiya are classified.

The gravel analysis revealed that the gravel of Mukdadiya Formation in both sections (Amadiya and Zakho) is composed mainly of sedimentary and igneous gravel, as well as metamorphic gravel in small amount. That indicates it's derived mainly from sedimentary and igneous sources mainly and less metamorphic sources.

The petrographic investigations revealed that the sandstone of Injana and Mukdadiya Formations are composed primarily of rock fragments (sedimentary, igneous and metamorphic), quartz grains (monocrystalline and polycrystalline), and feldspars (orthoclase, microcline, perthite and plagioclase). These components are bound by carbonate cement. The percentage of quartz grains in Injana Formation is more than the percentage of quartz in Mukdadiya Formation, and the percentage of rock fragments in Injana is less than the percentage of rock fragments in Mukdadiya

sandstone. The suggested provenance for the concerned Injana and Mukdadiya Formations are primarily sedimentary and igneous rocks and the less dominant metamorphic rocks. These sandstones are classified as Litharenites and mineralogically immature.

X-ray diffraction analysis for the mudstone unit of Injana and Mukdadiya Formations at Zakho sections shows that the clay minerals are: montmorillonite, illite, and kaolinite. These minerals refer to that it derived mainly from acidic igneous and sedimentary and less dominance metamorphic and ultrabasic igneous source rocks, it is also referring arid to semi-arid climate.

The heavy minerals assemblages include opaque minerals as major component, epidotes, garnet, amphiboles, clinopyroxenes, orthopyroxenes, chromian spinel, zircon, tourmaline, rutile, chlorite, biotite, muscovite and others (kyanite and staurolite). These assemblages indicate that the heavy minerals are derived from mafic igneous and metamorphic rocks mainly as well as acidic igneous and reworked sediments. The tectonic provenance for Injana and Mukdadiya Formations can be described as recycled orogen.

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