

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Technical Letter
Saudi Arabian Mineral
Exploration - 19
Prepared April 20, 1965
Issued August 30, 1965

Dr. Fadil K. Kabbani
Deputy Minister for Mineral Resources
Directorate General for Mineral Resources
Ministry of Petroleum and Mineral Resources
Jiddah, Saudi Arabia

Dear Dr. Kabbani:

Transmitted herewith are 10 copies of:

TECHNICAL LETTER NUMBER 19
NOTES ON RUBIDIUM-STRONTIUM
GEOCHRONOLOGY

by

Richard H. Reesman*

Sincerely,

Glen F. Brown
Glen F. Brown, Chief
Saudi Arabian Mineral Exploration Project

* U. S. Geological Survey, Jiddah, Saudi Arabia

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Richard H. Reesman*

Introduction

This brief discussion of rubidium-strontium geochronology, is to be used as a guide in the selection of samples submitted for age dating at the Geochronological Laboratory of the Ministry of Petroleum and Mineral Resources. It is not intended to be a full review of the technique.

Rubidium-strontium geochronology

The utility of the rubidium-strontium method of geochronology lies in the fact that, although neither Rb nor Sr are common mineral forming elements, Rb is closely associated in nature with potassium, and Sr is closely associated with calcium. Thus rocks with the common Ca and K bearing minerals are of use with this method.

Two methods of analyses are available. One is to analyze the whole rock sample, and the other is to analyze separated mineral fractions (e.g. feldspar, biotite, muscovite, etc.). For fresh rocks which have remained closed systems with respect to Rb and Sr since their time of formation, the whole-rock ages are as reliable as are the ages on the separated minerals. As the time involved in the preparation of a whole-rock sample is considerably less than that for a separated mineral, it is desirable to make a whole rock analysis, whenever possible.

For Rb-Sr geochronology it is necessary to determine the amounts of Rb and

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Sr present in the sample and the Sr isotopic composition of the sample. Weathering and/or alteration affect these measurements in two distinct ways. The first effect is in the alteration of the absolute and relative amounts of Rb and Sr in the sample; the second effect is in altering the Sr isotopic composition. Rb^{87} decays to Sr^{87} and thus the radiogenically produced Sr^{87} is located in the potassium minerals in the original site of the Rb, a potassium lattice site. The weathering of a K-rich mineral, then, selectively removed Rb and Sr^{87} , lowering the Rb/Sr ratio and altering the Sr isotopic composition of the sample as a whole. Conversely the weathering of a Ca-rich mineral may greatly increase the Rb/Sr ratio of the sample and may also greatly alter the Sr isotopic composition of the sample. Samples chosen for whole rock age determinations should therefore be as absolutely free from weathering and alteration as it is possible to obtain. Any weathering which is visible macroscopically forecasts inaccurate age determinations. For medium and fine grained rocks a hand-specimen size sample should be sufficient for a whole rock age determination. For very coarsely crystalline rocks the diameter of the entire sample should be at least ten times the diameter of the largest mineral grains.

An analysis on a single whole rock or mineral sample from a given rock unit is at best only an approximation of the age of the unit and should not be construed to be anything more. If a more reliable age analysis is required for a given rock unit(s), several samples from the unit should be submitted so that an isochron study can be made on the samples. (See last page.) In this event the samples should best be taken from widely scattered localities in the rock unit, if possible, and several samples should be taken a few tens of feet apart at each locality. The samples should be representative of the varying mineralogy and degrees of grain size of the rock, and should be chosen, on the basis of mineralogy, so as to have varying K/Ca (and thus Rb/Sr) ratios. At least one sample with an apparently low Rb/Sr ratio should be submitted in order to "tie-down" the lower end of the isochron.

If it is not feasible to collect several fresh whole rock samples from a given unit, it may still be possible to make an isochron study on one good sample by analyzing the whole rock and/or two or more minerals within the rock.

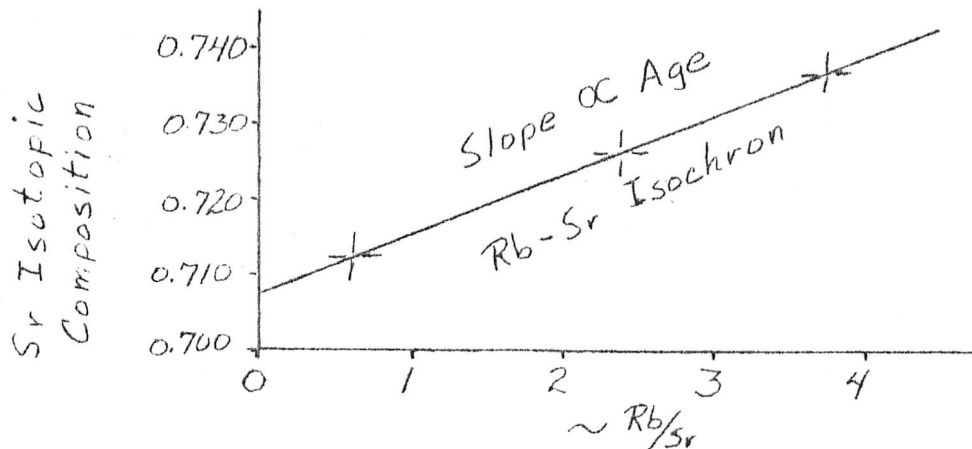
In this case there is little or no choice of Rb/Sr ratios with which to work and the analytical results may be of lower quality than those from several separate samples.

If clean, fresh whole rock samples are not available, age determinations can still be made on separated mineral fractions, if unweathered and unaltered minerals are present in the rock. Experience has shown that the reliability of minerals in the Rb/Sr method is approximately the reverse of the reaction series. Muscovite is the most reliable, followed by potassium feldspar, plagioclase and biotite. Again, it is advisable to submit more than one such sample so that some choice of Rb/Sr ratio is available, and samples should be submitted which will yield several grams of the separated mineral. For samples submitted for a single analysis, whether whole rock or mineral, a Rb/Sr ratio greater than one is desirable.

Because of the limited size of the crushing equipment in the laboratory and the limited laboratory help, each geologist must be responsible for the initial breaking of the samples into pieces of a size suitable to fit into the jaws of the crusher, i.e. about one inch. It is also desirable to have one piece, perhaps twice this size, which is fairly representative of the entire sample, and which can be kept with the crushed sample to serve as a miniature hand specimen.

Isochron analyses

The utility of an isochron plot arises from the fact that if we plot the Sr isotopic composition vs (approximately) the Rb/Sr ratio for a suite of whole rock or mineral samples from a single rock unit of homogeneous age, these samples will define a straight line whose slope is a function of the age of the samples and whose ordinate intercept is the original Sr isotopic composition of the samples.



An isochron analysis, therefore, gives us an indication of the reliability of the age analyses, and the initial Sr composition of the samples, the second of which, for single analyses, can only be estimated.