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Natural radioelement concentration in the Troodos Ophiolite Complex of Cyprus

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Abstract

High-resolution γ-ray spectrometry was exploited to determine naturally occurring thorium (Th), uranium (U) and potassium (K) elemental concentrations in the whole area covered by the Troodos Ophiolite Complex of Cyprus. For that purpose, a total of 59 samples from surface soils and 10 from the main rock formations of the region of interest were analysed. Elemental concentrations were determined for Th (range from 2.5×10^{-3} to 2.0 ppm), U (from 8.1×10^{-4} to 0.6 ppm), and K (from 1.3×10^{-4}% to 1.0%). The average values (A.M±S.D.) derived are (0.24±0.34) ppm, (0.10±0.10) ppm and (0.21±0.24)%, for Th, U, and K, respectively, in the soils, and (0.52±0.17) ppm, (0.17±0.11) ppm and (0.49±0.87)% in the rocks. From these values, a radioactivity (radioelement) loss of nearly 50% is estimated in the underlying surface soils due to leaching and eluviation during weathering of the rocks. The measured Th/U ratio exhibits values between 2 and 4, whereas the K/Th ratio is highly variable ranging between 1.5×10^{3} and 3.0×10^{4}.

Keywords: Natural radioactivity; Gamma radiation; Radioactivity loss; Soils; Rocks; Elemental concentration; Potassium; Thorium; Uranium; Troodos Ophiolite; Cyprus

1. Introduction

The main external source of irradiation to the human body is represented by the gamma radiation emitted by naturally occurring radioisotopes, also called terrestrial environmental radiation. These radioisotopes, such as ^{40}K and the radionuclides from the ^{232}Th and ^{238}U series and their decay products, exist at trace levels in all ground formations. Therefore, natural environmental radioactivity and the associated external exposure due to gamma radiation depend primarily on the geological and geographical conditions, and appear at different levels in the soils of each different geological region (UNSCEAR, 2000 Report, and further references cited therein). The specific levels of terrestrial environmental radiation are related to the geological composition of each lithologically separated area, and to the content in

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thorium (Th), uranium (U) and potassium (K) of the rock from which the soils originate in each area.

The island of Cyprus is located in the eastern basin of the Mediterranean Sea and extends to an area of about 9300 km^2. Its characteristic geological formations can be classified into two broad main categories: those that belong to an ophiolite complex (extending to an area of about 3000 km^2) and those of sedimentary origin (Fig. 1). The Cyprus ophiolite is one of the best preserved and most intensively studied ophiolite complexes in the world, and is known as the Troodos Massif or Troodos Ophiolite Complex (Moores and Vine, 1971; Robinson and Malpas, 1998).

The large geological significance of the Late Cretaceous Troodos Ophiolite is focused on its complete and non-disruptive sequence tougher with a displaced slab of altered ultrabasic and basic plutonic complex, stratigraphically overlain successfully by a sheeted dyke complex, extrusive sequence and pelagic sediments (Moores and Vine, 1971; Gass, 1980). Troodos is believed to have formed at several spreading axes in a supra-subduction zone environment as a result of the collision of the African and Eurasian Plates in the Late Cretaceous (Robinson and Malpas, 1998). Geological conditions in the area maintained the whole ophiolite stratigraphy unimpaired through centuries and, hence, both the Troodos Ophiolite Complex and the ocean crust have exactly the same layer structure (Fig. 2). Due to subsequent erosion, the primary upward succession of ophiolite stratigraphy was arranged in an outward succession from centrally exposed plutonic rocks to a sheeted dyke complex and peripheral pillow lavas

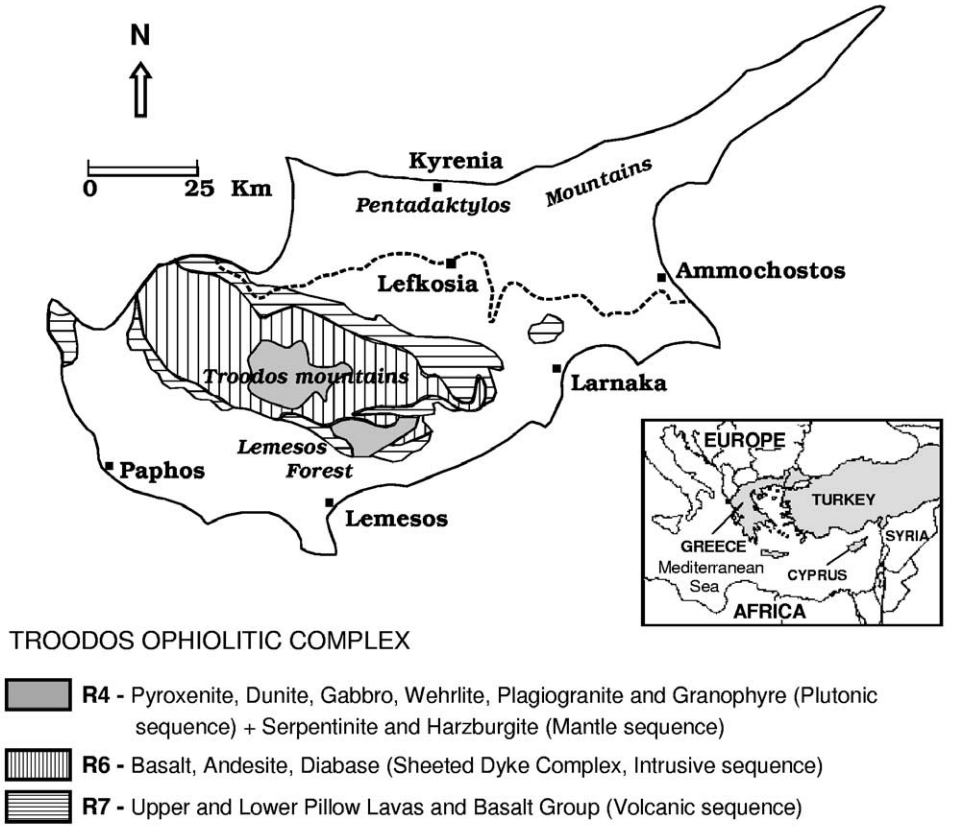

Fig. 1. Simplified geological map of Cyprus, indicating the Troodos Ophiolitic Complex with its three geological regions discussed in this survey; the various rock formations appearing are described in the legend.