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Dose estimation, kinetics and dating of fossil marine mollusc shells from northwestern part of Turkey

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HIGHLIGHTS

- In this manuscript, aragonitic marine fossil shell samples were investigated for the purpose of ESR dating.
- The thermal stability and dose response of the ESR signals were found to be suitable for an age determination using a signal at $g=2.0015$.
- This study reports the first dating results on fossil shells taken from Çanakkale (Turkey)-İkizlerçeşme marine terrace deposits.

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ABSTRACT

Electron spin resonance (ESR) spectroscopy was used to determine the geological formation age of fossil mollusc shells taken from marine terrace deposits (İkizlerçeşme-Çanakkale) in northwestern part of Turkey. This work reports the first results obtained by the ESR technique on shells collected from this region. In the ESR spectra of the natural and γ-irradiated shell samples, two different signals attributed to orthorombic ($g_{xx}=2.0030$, $g_{zz}=2.0015$, $g_{yy}=1.9980$) and isotropic ($g=2.0006$) CO_2^- ion radicals were overlaped (Signal C). Annealing and kinetic experiments suggest the possibility of using the ESR signal at $g=2.0015$ (C signal) for the estimation of accumulated geological doses. The ESR signal growth curve on additional gamma irradiation has been best fitted by a combination of two single exponential saturation functions. This may support the existence of at least two components of the $g=2.0015$ ESR dating signal. Based on this model, the accumulated dose of the samples was determined as 110 ± 11 Gy. Also the isothermal decay curves of the ESR dating signal could be best described by the combination of two first order decay functions. Activation energy and meanlifetime values at 15 °C of the two components were calculated as $E_1=1.4\pm0.1$ eV, $E_2=1.1\pm0.1$ eV, $\tau_1=7.2\times10^6$ years and $\tau_2=3.3\times10^3$ years, respectively. Uranium content of the studied shells was found to be high according to their chemical analysis. This may point out that the marine shell has received uranium from outside particularly in carbonate sediment. Therefore, the ESR age of the samples was also calculated using Early Uptake (EU), Linear Uptake (LU) and Combined Uptake (CU) models and results were discussed.
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1. Introduction

Çanakkale strait (Dardanelles) in Turkey is a 62 km long water passage connecting the Aegean Sea and the Marmara sea. Its NE-trend is interrupted by a north–south direction bend between Eceabat and Çanakkale. Its width varies from 1.2 to 7 km, the narrowest part being located near the cape Nara, about 25 km east of its Aegean Sea connection. The average depth of the strait is 55 m Yaltırak et al., 2000; Avcıoğlu et al., 2013). Similar to the main physiographic trends of the adjacent Gelibolu and Biga peninsulas, it lies approximately in a NE-to-SW direction, except for an abrupt E–W deviation in the middle where Cape Nara protrudes (Avcıoğlu et al., 2013).

Marine terraces along the Strait of Çanakkale coast provide valuable clues for understanding the recurrence of water exchanges between the Mediterranean Sea and the Black Sea during the late Pleistocene and deciphering tectonically induced uplift

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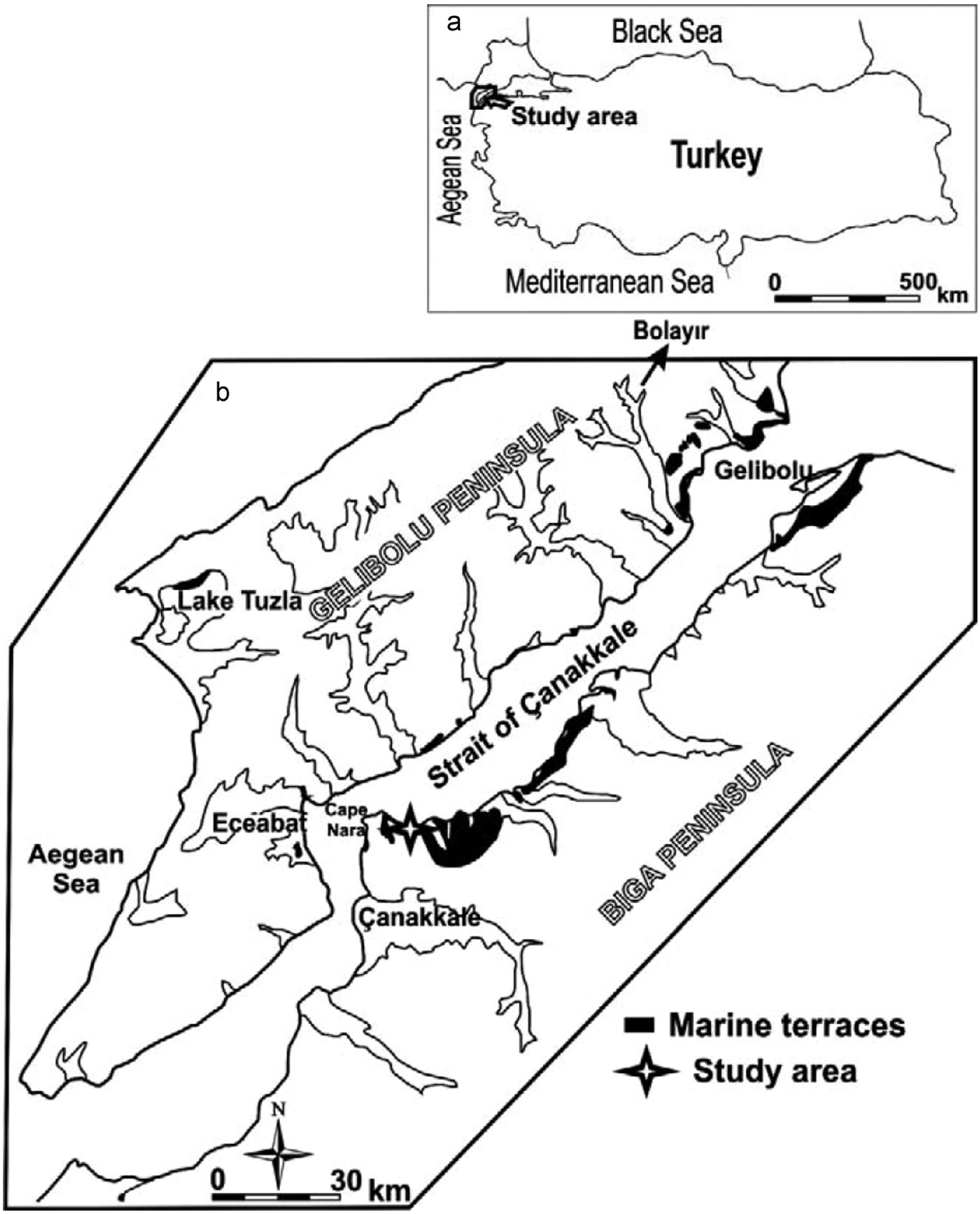

Fig. 1. (a) Map of Turkey showing the location of Çanakkale (study area) (b) Shaded regions represent marine terraces along Çanakkale Strait (from Avcıoğlu et al. (2013)).

rates (Avcıoğlu et al., 2013). Marine terraces around the Sea of Marmara are called the Marmara formation, typical examples of which exist at approximately 15 different localities along both sides of the Strait of Çanakkale (Avcıoğlu et al., 2013). These deposits are of wide extension to the east of cape Nara (Fig.1), and their paleogeographical importance has been emphasized by several authors. Although the results on the distribution, fossil contents and sedimentological characteristics of these shallow marine deposits have been given in great detail (Erol and Nuttal, 1973; Sakınç and Yaltırak, 1997), little works have been performed by using U/Th and Optically Stimulated Luminescence (OSL) techniques (Yaltırak et al., 2002; Avcıoğlu et al., 2013) which attempt to determine the absolute age of these deposits.

In recent years, Electron Spin Resonance (ESR) technique has also been used for dating Quaternary fossils of mammals, human remains and shells of both marine and terrestrial molluscs (Molodkov, 1988; Barabas et al., 1992a, 1992b; Molodkov, 1993; Schellmann and Radtke, 1997, 1999; Engin et al., 2006; Kinoshita et al., 2006, Kerber et al., 2011). This technique is useful for Quaternary fossils because it can determine ages older than the maximum limit of ^{14}C (about 50,000 years) its upper limit is dependent on the saturation of defects and signal stability in older samples and on the thermal stability of the defects (Ikeya and Ohmura, 1981; Radtke et al., 1985; Shimokawa et al., 1992; Ikeya,

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