MINERALS IN THE HUMAN BODY

Erionite and offretite from the Killdeer Mountains, Dunn County, North Dakota, U.S.A.‡

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ABSTRACT

The carcinogenic potential of erionite has sparked concern about human exposure in areas where it is present in regional bedrock. The Arikaree Formation in western North Dakota contains altered tuffaceous units with authigenic zeolites. We sampled stratigraphic profiles in the Killdeer Mountains, Dunn County, North Dakota, to determine the distribution and chemical composition of zeolites. Powder X-ray diffraction, SEM/EDS and electron microprobe analyses were carried out on sample concentrates. Only samples stratigraphically in or below the distinctive burrowed marker unit were found to contain zeolites. Erionite and offretite were the most common zeolites identified, with offretite being more abundant based on frequency of measured Mg/(Ca+Na) ratios. Intermediate chemical compositions could be natural or due to intimate intergrowths of the two minerals. A better understanding is needed of the potential toxicity across the range of erionite and offretite compositions.

Keywords: Erionite, offretite, zeolite, Killdeer Mountains, North Dakota, Arikaree

INTRODUCTION

During the late 1970s, an epidemic of mesothelioma was discovered in three villages in the Cappadocian region of central Turkey (Baris et al. 1978; Arrtvinili and Baris 1979). Subsequent studies investigated the link between the high incidence of deaths within the group caused by malignant pleural mesothelioma (MPM) and the occurrence of erionite in the region’s bedrock (Baris et al. 1987). Emigrants from the region were found to have increased risk of MPM and 49% or more of the deaths in the Cappadocian region of Turkey due to MPM had a potential link to erionite exposure (Metintas et al. 1999). It was reported that 78% of the deaths that had occurred in the study group were due to malignant mesothelioma, and it is estimated that 50% of the total deaths in the area can be attributed to mesothelioma (Metintas et al. 1999; Emri et al. 2002).

Experimental studies show erionite has up to 300–800 times more carcinogenic potency and may be 20–40 times more active than some asbestos forms (U.S. EPA 2010). It has been classified as a Group I carcinogen by the International Agency for Research on Cancer (IARC 1987). Physical and chemical differences between the minerals could explain these differences (Emri et al. 2002). Supporting studies on rats have shown that inhaled erionite fibers resulted in increased incidence of mesothelioma in those animals (Wagner et al. 1985). A North American case of mesothelioma attributed to erionite exposure was reported by Kliment et al. (2009), however the mineral identification did not include a crystallographic tool such as XRD or TEM. Increasing interest in the subject prompted many more studies on the health effects of erionite, as well as new investigations into its carcinogenic potential, mechanisms of carcinogenesis, and potential genetic predispositions (Carbone and Yang 2012), its identification and classification (Dogan and Dogan 2008), erionite mineral structure, and the similarities between the mineral erionite and other closely related zeolites. A summary is provided by Carbone et al. (2007).

The concern with the carcinogenic potential of erionite has sparked an interest within North Dakota and other areas containing erionite in regional bedrock or sediments. These areas include other high butte formations scattered across western North Dakota as well as the badland formations of North Dakota, South Dakota, and Montana (Goodman and Pierson 2010). There is concern with exposure and transmission of airborne dusts and particulates possibly containing erionite fibers from gravel pits, roads, parking lots, playgrounds, feed lots, building and construction, mining operations, oil extraction, and farming/ranching operations (Carbone et al. 2011; Maher 2010). The study reported here was undertaken to characterize the distribution and chemical composition of erionite and related zeolites in rocks exposed in the Killdeer Mountains of Dunn County, North Dakota.

GEOLOGIC SETTING AND PREVIOUS WORK

Bluemle (2000), Murphy (2001), Murphy et al. (1993), and Hoganson et al. (1998) provide descriptions of the general geology, the geologic time setting, and the past geologic processes that resulted in the formations and stratigraphy found in the study area.