Raman spectroscopic and microscopic criteria for the distinction of microdiamonds in ultrahigh-pressure metamorphic rocks from diamonds in sample preparation materials

MARIA PERRAKI,1,* ANDREY V. KORSAKOV,2 DAVID C. SMITH,3 AND EVRIPIDIS MPOSKOS1

1School of Mining and Metallurgical Engineering, National Technical University of Athens, 9 Heron Politechniou St., GR-15773, Zografou, Athens, Greece
2Institute of Geology and Mineralogy, Siberian Branch of the Russian Academy of Sciences, Koptyug Pr. 3, Novosibirsk 630090, Russia
3Laboratory of Extraterrestrial Materials and Nanoanalysis, Muséum National d’Histoire Naturelle, 61 Rue Buffon, 75005 Paris, France

ABSTRACT

Natural diamond from three ultrahigh-pressure metamorphic (UHPM) terranes (Erzgebirge Massif, Germany; Kokchetav Massif, Northern Kazakhstan; Rhodope Metamorphic Province, Greece) and synthetic diamond from cutting and polishing materials (paste, spray, saw blade) were studied by means of optical microscopy and Raman microspectroscopy, to constitute a new petrographic and spectroscopic data set that might be a useful tool for identifying and characterizing metamorphic diamond. Several criteria are established for distinguishing natural microdiamond identified in a rock thin section from the externally introduced ones [i.e., diamond as residual particles (contaminants) from the cutting and polishing material] such as the diamond size, the presence of inclusions, coatings, or coexistent phases and two diamond Raman band parameters, i.e., the Raman shift and the full-width at half maximum height (FWHM).

Keywords: Diamond, Raman, UHP metamorphism, Kokchetav, Erzgebirge, Rhodope Metamorphic Province

INTRODUCTION

During the last 20 years, the number of localities found to have crustal rocks containing coesite, diamond, or other ultrahigh-pressure (UHP) metamorphic mineral phases, assemblages, and textures have steadily increased. Ultrahigh-pressure metamorphism (UHPM), up to 40–45 kbar (Lappin and Smith 1978), initially considered as a petrological peculiarity, has now become recognized as a common feature of continental plate collisional orogens. Typical UHP minerals are the high-pressure polymorphs of SiO2; and of carbon, respectively, coesite and diamond. Preserved coesite inclusions (often surrounded by quartz with palisade texture) and/or polycrystalline quartz inclusions surrounded by radial cracks in robust minerals (e.g., garnet, zircon, pyroxene, and rarely kyanite) deduced to be pseudomorphs after coesite have been cited as evidence of UHPM conditions (e.g., Chopin 1984; Smith 1984; Zhang et al. 1997; Liu et al. 2001). Diamond-bearing rocks are less common than coesite-bearing rocks. Since the pioneering work by Sobolev and Shatsky (1990) in which they reported for the first time the presence of diamond inclusions in garnets and of Claoue-Long et al. (1991) who reported diamond inclusions in zircon from metamorphic rocks from the Kokchetav Massif, Northern Kazakhstan, microdiamonds have been identified as inclusions in garnet, zircon, clinopyroxene, kyanite, zoisite, biotite, and muscovite in a variety of metamorphic terranes and lithologies all over the world (e.g., Ogasawara et al. 2000; Korsakov et al. 2002; Godard et al. 2004; Smith et al. 2004; Sobolev et al. 1994; Chopin and Sobolev 1995; Korsakov and Hermann 2006; Mposkos and Krohe 2006; Perraki et al. 2006; Vrijmoed et al. 2008).

Although the unambiguous identification of coesite brings to light a new UHPM location, finding diamond requires further investigation. Once the presence of diamond is affirmed, its origin must be evaluated. Researchers must eliminate the possibility that diamond was the result of contamination from the cutting and polishing materials (saw blade, paste, powder, spray, etc.). Diamond found in metamorphic rocks has been controversial since the identification of microdiamonds, collected by acid dissolution, in kyanite gneisses on Fjörtoft Island, Norway (Dobrzhinetskaya et al. 1995). Some researchers were, and still are, reluctant to believe that the diamond crystals in this study were part of the gneiss, since they were not observed in thin section but rather were collected in the residue of acid dissolution of the whole rock. Subsequently, microdiamonds at three other Norwegian localities [Bardane, Straumen, and Svarberget described respectively by Van Roermund et al. (2002), Godard et al. (2003, 2004), and Vrijmoed et al. (2008)] provided support to the verity at Fjörtoft. Likewise, Beyssac and Chopin (2003) considered the SEM images of diamond from the Rhodope Metamorphic Province, Greece, presented by Mposkos and Kostopoulos (2001) to be ambiguous as they claimed that the surficial diamond could actually be an artifact of thin section preparation. Subsequent publications added convincing data to support the presence of real microdiamonds in the Rhodope Metamorphic Province,