

DIASPORESCENCE IN RUBIES FROM PRILEP DOLOMITIC MARBLE[♦]

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Rubies from the Prilep dolomitic marble contain numerous diaspore inclusions, resulting from oriented intergrowth with corundum. In the world of gemstones, this phenomenon has been recognized as diasporescence, which has to date been researched only in the cases of corundum crystals from Macedonia. The paper describes the importance of diasporescence for the appearance and thus the quality of rubies, in which the inclusions of diaspore are also a distinctive character for the determination of the origin of this renowned gemstone. Diaspore is colourless to white and affect on intensity of red to pink colour of ruby as a gem. Macedonian rubies are the only rubies from around the world with inclusions of diaspore and that's why also the only rubies with optical phenomena diasporescence.

Keywords: ruby; marble; diasporescence; Sivec; cutting

ДИЈАСПОРЕСЦЕНЦИЈА НА РУБИНИТЕ ОД ПРИЛЕПСКИОТ ДОЛОМИТСКИ МЕРМЕР

Рубините од прилепскиот доломитски мермер содржат бројни инклузии од дијаспор кои произлегуваат од ориентираните сраснувања со корунд. Во светот на скапоцените камења овој феномен е познат како дијаспоресценција и до денешни дни е изучуван само кај кристалите на корунд од Македонија. Во трудов е опишано значењето на дијаспоресценцијата за појавата и квалитетот на рубините, кај кои инклузиите од дијаспорот се од клучно значење за одредувањето на потеклото на овој вреден скапоцен камен. Дијаспорот е безбоен до бел и влијае врз интензитетот на бојата на рубинот како скапоцен камен, која варира од црвена до розова. Македонските рубини се единствени во целиот свет со инклузии од дијаспор, што ги прави единствени и според појавата на феноменот дијаспоресценција.

Клучни зборови: рубин; мермер; дијаспоресценција; Сивец; сечење

1. INTRODUCTION

Rubies, these gem varieties of the mineral corundum (Al_2O_3), acquire their characteristic red colour particularly from the admixture of chrome and/or iron. Since ancient times, they have been appreciated owing to their colour and hardness, given that corundum is the third hardest mineral after diamond and moissanite. Although corundum is fairly common, the ruby deposits are much rarer. And among all ruby deposits in the world, the ones from Prilep dolomitic marble are something very

special indeed. They are orientedly integrown with the mineral diaspore, which gives them a special appearance and characteristics that strongly influence the evaluation of rubies as gems.

1.1. Geological setting

The rubies from the neighbourhood of Prilep in Macedonia are found in marbles belonging to the central part of the Pelagonian Massif. They have been formed through metamorphism of carbonate rocks. The marble series, which is the last

[♦] Dedicated to Academician Gligor Jovanovski on the occasion of his 70th birthday.

from the series of high-grade metamorphic rocks of the Pelagonian Massif, is no less than 1,500 metres thick [1]. Although these marbles outcrop at several sites, mainly three localities are known as far as finds of corundum are concerned: Sivec, Beloto and Belovodica [2]. The most important site of corundum and therefore rubies is the Sivec quarry, which is situated 8 kilometres northwest from Prilep at the foot of Sivec Hill and in which high quality and often completely snow-white dolomitic marble is extracted [3] (Fig. 1).



Fig. 1. View of Sivec, dolomitic marble quarry in Macedonia.
Photo: Zvonko Gruevski

Special attention has always been drawn by specimens of corundum and diasporite visible to the naked eye, and other accompanying minerals such as fluorite, rutile, micas, dolomite, zoisite, achroite, pyrite, muscovite, illite, margarite, chlorite and kosmatite [2]. The find of diasporite in the second half of the 20th century was for a number of years considered even an unusually large crystal of this mineral [4], which is morphologically described in detail [3, 4].

In the dolomitic marble, corundum is bound to calcite nests. Morphologically, they are diversely shaped and can develop flat, barrel-like, prismatic and even rhombohedral crystal [5]. They are usually light pink, less often intensive red, while the rarest are blue. The pink to red colour of the Prilep corundum is influenced by the admixture of chrome, vanadium and iron, whereas the blue colour is influenced by titanium [5]. Owing to the admixtures of the mentioned colouring ions, particularly chrome and vanadium, the corundum of Prilep dolomitic marble fluoresces red, orange and yellow. The special feature of corundum of the Prilep dolomitic marble is its oriented intergrowth with diasporite [6, 7], which is recognized in the

world of gemstones as a new optical phenomenon diasporite [8]. Diasporite in corundum crystals is oriented in three directions crossing at 60 degrees, resembling a sphenite-like structure [7]. Diasporite is a kind of silvery glittering, which is manifested as a white reflection on the surface of cabochon [9] and has been classified as an optical phenomenon into gemmological terminology [9]. Intensive oriented intergrowth of diasporite and corundum has an impact on gem density, as diasporite has lower density than corundum. Rubies of the Prilep dolomitic marble thus have the density ranging from 3.53 and 3.93 g/cm³ [5], which is less than the density of rubies (3.97 to 4.05 g/cm³) and more than the density of diasporite (3.39 to 3.40 g/cm³) [10]. Rubies from Macedonia have been described in professional gemmological literature very rarely [11], or just individual data are given as far as their physical characteristics are concerned [12]. It is interesting that diasporite is not described as an inclusion in rubies from other localities [13]. This means that diasporite is not only a new optical phenomenon in the world of precious stones, but also an optical phenomenon that stipulates the origin of rubies from the Sivec quarry in Macedonia [5].

2. MATERIALS AND METHODS

We examined more than 100 corundum specimens from the Prilep dolomitic marble and selected 22 specimens for cutting. We recognized corundum and diasporite with x-ray diffraction of powdered samples in previous studies of this material [5]. Furthermore, we were asked to examine another 11 specimens of already cut Prilep rubies from private collections. The specimens were checked macroscopically and with the aid of 10× magnification loupe. The selected specimens were cut perpendicular to the rhombohedron planes with a diamond blade, ground with a diamond grinding wheel and polished with a diamond paste [14] in the workshop of the Higher Education Centre in Sežana.

3. RESULTS AND DISCUSSION

3.1. Macroscopic examination

The majority of corundum crystals develop only part of crystal faces. Most often, the face of basic pinacoid and hexagonal bipyramid and rhombohedron is present. The crystals are partly covered with limonite and therefore brownish, but

are mostly light pink. They ranged from 1.5 to 6 cm in size. On the basis of their homogeneity, we chose 22 specimens from more than 100 samples for further treatment and examined them with a 10× magnification loupe.

3.2. Examination with a 10× magnification loupe

The corundum samples were examined with a 10× magnification loupe in refracting and reflecting white light. It was concluded that the corundum was intensely intergrown with diaspore, as the silvery glittering, which is caused by reflection of light from diaspore crystals, was frequent. We marked the parts of crystals that were hollow, since such crystals parts are not applicable for grinding.

3.3. Orientation of crystals

The characteristic silvery glittering of diaspore in corundum is most intensive in the direction of rhombohedron faces. This was clearly visible on the edges, where diaspore crystals protrude from corundum (Fig. 2). This direction also helps us in the orientation of samples without developed crystal faces. Diaspore glittering is, specifically, present in all samples, irrespective of their external crystal form. Diaspore glittering is partially obscured only by the thin limonite coating or remains of rock-marble on the surface of corundum crystals.



Fig. 2. The corundum crystal of gem quality (6 cm high) is overgrown with diaspore with well visible silvery reflection.
Photo: Cyril Mlinar

3.4. Grinding and polishing of the samples

The corundum samples were cut parallel to rhombohedron planes or transversely onto them. We decided to grind them into cabochons, then marked their basic form, oval in most cases. It was

already the rough grinding of the basic form that revealed the quality of crystals, as hollowness of the material was manifested in most samples. Most of the samples (about 80%) had intensive lamellae of diaspore, while in others they were less prominent. It was assessed that rough grinding of the form with diamond grinding wheels was the most vulnerable part of the processing, given that due to diaspore inclusions in corundum the latter could split along parting planes. If finer grinding wheels were used, this danger was not detected. First of all, the lower flat parts were subjected to grinding, then the upper semi-circular forms. The biggest challenge in the grinding of rubies from the Prilep dolomitic marble is their polishing. This has to do with the very diaspore in rubies, as diaspore is softer than ruby. The only way is polishing with diamond paste on a wooden disc impregnated with olive oil. Of the 22 samples that we wished to grind, only 9 were of suitable quality, while the rest were either hollow, too heterogeneous as far as their colour was concerned, or with distinct lamellae of diaspore and therefore less interesting for grinding.

3.5. Evaluation of rubies with regard to oriented diaspore intergrowth

The greatest challenge in cutting of rubies from Prilep dolomitic marble are diaspore inclusions. On corundum crystals they can be detected with the naked eye at first glance, even if the surface of corundum is covered with a thin layer of limonite. Diaspore inclusions in corundum are the result of oriented intergrowth of corundum and diaspore, which is the reason why diaspore as an inclusion is present through the entire corundum crystals. We can therefore conclude that diaspore has an immense impact on the appearance of rubies. If there is much of it, corundum crystals are lighter, at times even colourless or seemingly white. And vice versa. In cases when diaspore was not noticed already with the naked eye, and with some difficulty through a 10× magnification loupe, the colours of rubies were intense. Owing to the numerous inclusions-lamellae, the ground samples are translucent to opaque. It was also established that diasporoscence was most intense if the rubies were grounded in such a manner that the basic plane was parallel to the direction of parting. Then the silvery glittering was evenly distributed along the entire surface of cabochon, similar as annual rings in a tree (Fig. 3). Furthermore, diasporoscence is most intensive in light pink samples (Fig. 4). The reason for it is quite simple. In the most

intensely red ruby, the thin diaspore lamellae were detected with difficulty, but were well visible under a microscope or at greater magnifications (50× or more). In light pink to pink rubies, which are the commonest, the diaspore lamellae are usually thicker and thus more intensive. In the rubies that are subjected to grinding in such a way that their basic plane is perpendicular to the direction of parting it was established that diaspore was least noticeable and that the colour of the ruby was therefore most uniform (Fig. 5). The rarest were the cases of intensively red translucent rubies with diasporance and utterly transparent pinkish red rubies. During our ground samples research, two such patterns were discovered. In both, diaspore was noticed already with the naked eye, although only as an individual lamella that glitters silvery white (Fig. 6).

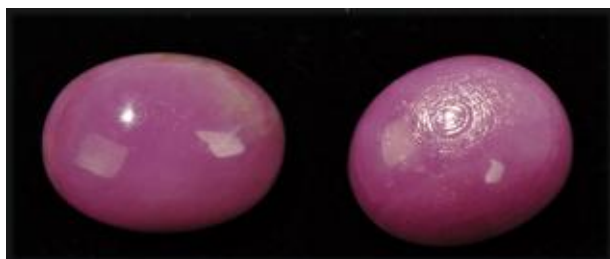


Fig. 3. Rubies with optical phenomenon of diasporance (right), which is manifested as silvery glittering of diaspore on the surface of rubies. On the left side is a ruby cut perpendicular to rhombohedron crystal faces with no visible diasporance to the naked eye. Photo: Miha Jeršek



Fig. 4. Rubies with very intense diasporance are light coloured. Photo: Miha Jeršek



Fig. 5. The basic plane of cabochon of ruby is perpendicular to the direction of parting and that the colour of the ruby was therefore most uniform. Photo: Ciril Mlinar



Fig. 6. Very rarely rubies from Prilep dolomitic marble are translucent and clean enough to cut as a faceting form. Diaspore inclusions are always present. Photo: Miha Jeršek

Rubies of the Prilep dolomitic marble are unique in the world of rubies, for they are the only ones that intergrow orientedly with diaspore. Diaspore inclusions are the element of recognisability, after which their origin can be determined as well: Sivec, Macedonia. With our research in the form of practical experiments of ruby grinding related to oriented intergrowth of corundum and diaspore we were able to conclude that knowledge of the basic crystallographic principles is very important and useful in practical grinding of Macedonian rubies. With respect to the orientation of cabochon we can, quite specifically, determine in advance the visibility of diasporance and thus exert influence on the final appearance of a gem (Fig. 7). Subject to ruby's orientation is also its colour, for when rubies are oriented with the basic plane perpendicularly to the direction of parting it is more uniform and at times even more intensive, as diaspore is less noticeable.

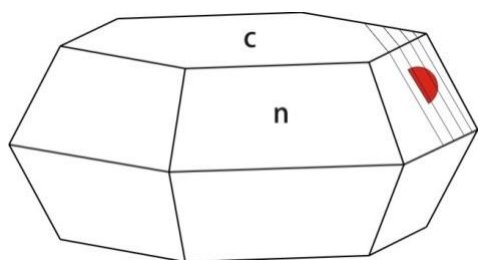


Fig. 7. Characteristic crystal of corundum from Prilep dolomitic marble has developed pinacoid **c**(001) and hexagonal bipyramid **n**(223). Lamellae of diaspor are parallel to rhombohedron planes and ideal orientation for cutting cabochons with optical phenomena diasporescence is orientation of cabochon perpendicular to that direction.

Diaspore inclusions affect not only the physical characteristics of rubies as gems [5], but have a distinct impact on the optical phenomenon of diasporescence as well [8]. With our experimental research we have also established that they also influence the transparency and intensity of colour shades in rubies from the Prilep dolomitic marble. And colour is certainly the feature that is noticed first and owing to which gems are particularly appreciated all over the world. Rubies of the Prilep dolomitic marble are so sought-after owing to their unique appearance which, however, is decisively influenced by the very diaspore inclusions orientedly overgrown in rubies (corundum).

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