Acta Mineralogica-Petrographica, Abstract Series 2, Szeged, 2003

FLUID INCLUSIONS IN THE IANAPERA EMERALD, SOUTH MADAGASCAR

VAPNIK, Ye.[1], SABOT, B.[2], MOROZ, I.[3]
[1] Department of Geological and Environmental Sciences, Ben-Gurion University of the Negev, P.O.Box 653, 84105 Beer-Sheva, Israel.
[2] BP 34, 42450 Sury le Comtal, France.
[3] Division of applied Physics, School of Applied Science, The Hebrew University of Jerusalem, 91904, Jerusalem, Israel.
E-mail : vapnik@bgumail.bgu.ac.il

The Ianapera emerald deposit is located at 200 km North East of Tulear, Vohibory region, South Madagascar. The Ianapera deposit belongs to Vohibory formations attributed to Precambrian age (Nicollet, 1985). The Vohibory formations are constituted by intermediate-pressure granulite facies to high-pressure granulite facies rocks. They are constituted by gneisses (orthogneiss and migmatitic gneiss), leptynites, marbles, serpentinites, amphibolites (some of them can bear corundum) and pyroxenites.

The emerald mineralisation is concentrated at the interaction between migmatitic gneisses (garnet-biotite-feldspar-quartz-sillimanite-disthene paragenesis) and serpentinites. Both lithologies are subject to a metasomatic alteration. Serpentinite shows a wide range of transition between non metasomatised composition characterized by an hourglass texture and those of a tremolite-carbonate-rich talcschist. Some veinlets of chrysolite are observed within the serpentinite. Metasomatised gneiss is characterised by a garnet-biotite-sillimanite-quartz-tourmaline paragenesis. The total width of metasomatic column is varying from 50 cm to 2 m.

The Ianapera deposit is located within the Ampanihy major shear zone described as rooted to the mantle and which direction (N10°) is controlled by a transpressional regime leading to pure shear in shear zone due to convergence of Dewhar craton westward and Tanzania and Zambian craton eastward during pan-African orogeny (Martelat et al., 1997).

Fluid inclusions were investigated in several chips of emerald. The microthermomertry, Raman spectroscopy and SEM were used for the study. Fluid inclusions show mainly spacious distribution. In a single case inclusions were found in trail elongated along emerald growth face. Inclusions are evidently of primary origin. Several types of inclusions are usually present within the single inclusion population (Fig. 1). (a) Multiphase inclusions composed from several birefringent and isotropic solid phases and aqueous solution with or without the gas bubble. Solid phases sometimes occupy up to 50-60 vol. % of fluid-inclusion volume. (b) Single phase CO_2-rich inclusions often with one or several birefringent and isotropic solid phases. CO_2 gaseous phase is appeared only during cooling runs. (c) Solid inclusions composed from multi-grained aggregates.

Aqueous multiphase inclusions show the first melting of ice mainly between –15 and -3°C whereas final melting was usually observed between –5 and –1°C. Most of the solid phases are insoluble during the heating, the homogenization of the gas bubble was observed mainly between 240 and 315°C. Solid phases are Raman active and considering the obtained spectrums are represented by dolomite, aragonite and calcite (Burke, 1994). In a few inclusions nahcolite was identified. Considering microthermometric data, finding of nahcolite and constant presence of carbonates within the inclusions the aqueous part is likely composed of HCO_3^--NaCl solutions. The salinity of solution is usually about 5 wt.% NaCl equiv.

CO_2-rich inclusions show the melting temperature around –57.5°C and homogenization between –17 and 8°C, most inclusions homogenize at –10°C. Considering Raman data the solid phases in CO_2-rich inclusions are also represented by carbonates.

Multi-grained solid inclusions are not Raman active and/or give the similar spectrum of emerald-host. Several inclusions were exposed by polishing on the surface and analyzed by SEM. SEM data on several inclusions show very similar results: analyses are carbon-rich with high silica, magnesium and aluminum contents. Considering element atomic ratios it seems that multi-grained inclusions are formed by beryl-emerald and magnesite aggregate.

Although all types of inclusions are usually present in the single inclusion population only a few aqueous-rich inclusions with CO_2 bubble occupying 5-10 vol. % of inclusion volume were observed. Joint occurrence of aqueous and CO_2 inclusions in the same primary populations of fluid inclusions is a strong argument on contemporaneous trapping of both fluid inclusion systems although generally low-salinity of the aqueous inclusions makes problematic the appearance of two fluid inclusions types due to fluid heterogenization.

The microthermometric data on the contemporaneous aqueous and CO_2 inclusions were used to evaluate the PT-conditions of inclusion trapping. Typical isochors and their intersection were used (Fig. 2). The field of isochors intersection is within the sillimanite stability field, at the PT-conditions of migmatite formation but has to be restricted by beryl stability field. The likely condition of inclusion trapping during the emerald growth are as follows: T=620-710°C and P=5-6 kbars. These exceptionally high PT-conditions of emerald growth are in accordance with the suggestion on metasomatic emerald formation in relation to high-grade metamorphic processes.

The Ianapera emerald is quite unique considering the emerald geological setting and emerald growth in highest PT-conditions that up to now were recorded for emerald formation (Groat et al., 2002).

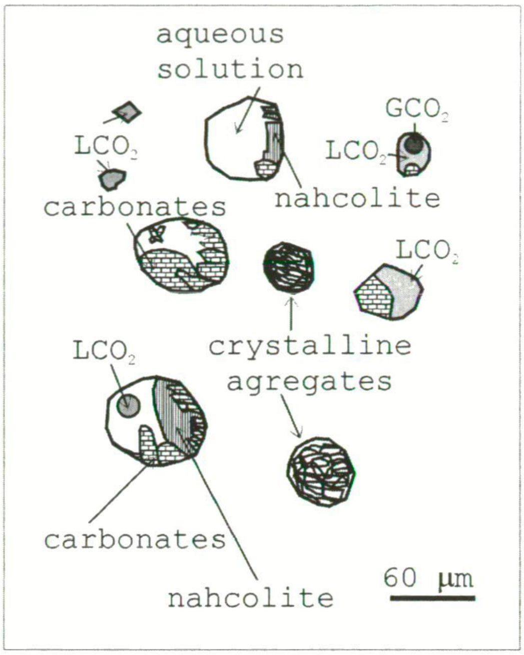

Figure 1.

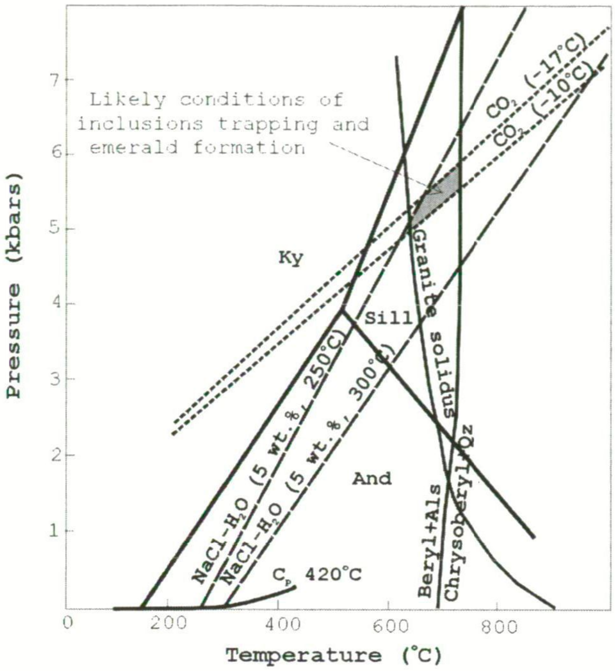

Figure 2.

Fig.1. Sketch of primary fluid-inclusion population projected to the plain.

Fig. 2. PT-conditions of the Ianapera emerald formation determined by the intersection of typical isochores of CO_2 (Schmulovich et al., 1982) and aqueous inclusions (Bodnar, Vityk, 1994). Kyanite-Sillimanite-Andalusite stability fields (Kerrick, 1990), beryl stability field (Barton, 1986) and water-saturated granite solidus (Johannes, Holtz, 1996) are shown in relation to the emerald growth.

References

BARTON, M. D. (1986): Phase equilibria and thermodynamic properties of minerals in the $BeO-Al_2O_3-SiO_2-H_2O$ (BASH) system, with petrologic applications. American Mineralogist, **71**, 277-300.

BODNAR, R. J., VITYK, M. O. (1994): Interpretation of microthermometric data for H_2O-NaCl fluid inclusions. B. De Vivo, M. L. Frezzoti (eds): Fluid Inclusions in Minerals: Methods and Applications. Virginia Tech, Virginia, USA, 117-130.

BURKE, E. A. J. (1994): Raman microspectrometry of fluid inclusions: The daily practice. B. De Vivo, M. L. Frezzoti (eds): Fluid Inclusions in Minerals: Methods and Applications. Virginia Tech, Virginia, USA, 25-44.

GROAT, L. A., MARSHALL, D. D., GIULIANI, G., MURPHY, D. C., PIERCEY, S. J., JAMBOR, J. J., MORTENSEN, J. K., ERCIT, T. S., GAULT, R. A., MATTEY, D. P., SCHWARZ, D., MALUSKI, H., WISE, M. A., WENGZYNOWSKI, W., EATON, D. W. (2002): Mineralogical and geochemical study of the Regal Ridge emerald showing, southeastern Yukon. The Canadian Mineralogist, **40**, 1313-1338.

JOHANNES, W., HOLTZ, F. (1996): Petrogenesis and Experimental Petrology of Granitic Rocks. Springer-Verlag, Berlin, Germany, 330 pp.

KERRICK, D. M. (1990): The Al_2SiO_5 polymorphs. P. Ribbe (ed): Reviews in Mineralogy, Volume 22. Mineralogical Society of America, Washington, D.C., 406 pp.

MARTELAT, J. E., NICOLLET, C., LARDEAUX, J. M., VIDAL, G., RAKOTONDRAZAFY, R. (1997): Lithospheric tectonic structures developed under high-grade metamorphism in the southern part of Madagascar. Geodinamika Acta, **10**, 94-114.

NICOLLET, C. (1985): The banded cordierite and garnet-bearing gneisses from Ihosy: a geothermo-barometric tracer in southern Madagascar. Precambrian Research, **28**, 175-185.

SCHMULOVICH, K. I., TERESHENKO, YE. N., KALINICHEV, A. G. (1982): Equation of state and isochores of non-polar gases up to 2000 K and 10 GPA. (in Russian), Geochimiya, **11**, 1598-1614.