POSSIBLE POST-IMPACT METAMORPHOSIS IN IMPACTITE GARNET; J. Raitala, University of Oulu, Oulu, Finland and T. Halkoaho, University of Turku, Turku, Finland

Garnets of staurolite-garnet schist and its impactite variety from the Lake Jänisjärvi impact crater in Karelia (61.58°N, 30.55°E [1]) were studied in order to find possible impact-related metamorphic changes. Garnets are ideal for such studies because they are common, more impact-resistant than most other minerals and their composition and zoning can easily be studied by microprobe. Garnets are stabile under high pressure because they are closely packed nesosilicate crystals with bulky hexoctaedral symmetry class without any main foliation nor cleavage. This garnet crystal resistance against high pressure and temperature is well displayed by their characteristic appearance in terrestrial mantle and high-grade metamorphic rocks. They have a rather fresh outlook even in impactite rocks studied. Their composition reflects the bulk composition of the rock, but they may also be sensitive indicators of changes in metamorphic or metasomatic environment. With increasing metamorphic grade garnets may change from manganese spessartite to almandine and pyrope [2]. This study describes possible compositional and diffusional changes in chemically zonal garnets from unaltered staurolite-garnet schist to its impact-influenced variety. Natural garnets consist mostly of several end members and also the analyzed almandine ($Fe_3^{2+}Al_2Si_3O_{12}$) garnets had some amount of pyrope ($Mg_3A_{12}Si_3O_{12}$), grossularite ($Ca_3Al_2Si_3O_{12}$) and spessartite ($Mn_3Al_2Si_3O_{12}$) representing thus the pyralspite group. The example garnet analysis A-D represent staurolite-garnet schist analyses from the crystal edge to the centre, respectively, while analyses a-d are from the crystal edge to the centre of an impactite garnet, respectively:

	A	B	C	D	a	b	c	d	Indicative element
Almandine	78.1	74.9	74.2	73.9	83.2	76.7	72.5	73.9	Fe_3^{2+}
Spessartite	7.5	11.3	12.2	12.2	3.7	9.5	12.8	11.4	Mn_3
Pyrope	8.8	7.9	7.5	7.6	7.0	6.5	5.0	4.1	Mg_3
Grossularite	5.6	5.9	6.1	6.3	6.1	7.3	9.7	10.6	Ca_3

In impactite garnet Fe^{2+} is higher close to the edge of the crystal than in unaltered almandine. There is a decrease Mn^{2+} at the edge of the garnet crystal while Mg^{2+} decreases and Ca^{2+} increases in the centre of the impact-influenced garnet. High pressure-temperature regime at the impact event and the thermal phase immediately after the impact may have given raise for some late metamorphic changes in the rock. The main shock-generated phase resulted in matrix of glass and milled crystal. Thermal metamorpic environment, present for an extended time after the impact event, may have been responsible for some amount of minor geochemical differences found between unaltered and shock metamorphic garnets. Diffusion may have changed even intact-looking garnet crystals when the impact-effected rock mass slowly cooled beneath the actual crater. High impact-related and post-impact temperatures may thus have caused diffusional cation exchanges between garnet crystals and the surrounding matrix in impactite rocks. The diffusion jump for a cation from a place to another needs a certain amount of activation energy. Such thermal energy was readily available just at and immediately after the impact. Diffusion was made easier by the impact-induced shock which, even if not able to break garnets, may have caused irregularities in crystal lattices. The number of dislocated or vacant crystal lattice locations increased with increasing energy ie. with increasing temperature and/or mechanical shock. Crystal lattice defects increased the diffusion coefficent and actual cation migration. Cation diffusion rate and diffusive distance depended also on crystal dimensions, composition of the matrix, peak temperature, temperature gradient, interdiffusion coefficient, and time. Longer paths of the cation migration through the crystal lattice make diffusion slower and more difficult. The hot post-impact rock was possible adequate to some Fe-Mg-Mn-Ca diffusion within impactite garnet crystals. Low pressure may have favored the Mn, Ca outflow and Fe, Mg inflow at garnet´s edges. More samples are, however, needed in order to gain statistically more conclusive data base.

References: [1] Raitala, J. & Halkoaho, T. (1992) Tectonophysics 216: 187-198.
[2] Mason, B. (1966) Principles of Geochemistry. John Wiley &Sons, NY.