DIAMONDIFEROUS MINERALS FROM THE STAR MINE, SOUTH AFRICA

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INTRODUCTION

Star Mine is located towards the eastern end of a series of East/West trending dykes and dyke enlargements situated approximately 15 km north east of Theunissen (O.F.S., Rep. S. Africa). The main 'Byrnes Dyke' is a micaceous kimberlite with an average diamond grade of not less than 0.4cts. per tonne which has proved economically viable and produces extremely good quality stones of excellent shape and colour. One characteristic of the production is the scarcity of yellow diamonds. This kimberlite occurrence has many similarities with the better described Bellsbank Fissure system. It has been classified petrographically as a Type II kimberlite and assigned a 124 m.y. (K/Ar) age by other workers. Garnet and chromite are significant components of the mantle derived heavy mineral fraction in the Byrnes kimberlite but ilmenite is very rare.

DIAMOND INCLUSIONS

Reconnaissance observations of the inclusions (in only 59 diamonds) suggest that peridotitic minerals predominate. There is a major component of chromites. Eclogitic mineral inclusions have been observed in minor amount.

DIAMONDIFEROUS MINERALS

Twenty-two small (<2cm) samples of silicate minerals which have diamonds embedded chiefly in their outer surfaces have been found at Star.

In contrast to the diamond inclusions, these macrocrysts have a predominantly eclogitic association: one consists of eclogitic garnet, clinopyroxene and diamond, and nineteen are eclogitic garnets with one or more diamonds protruding from each grain.

One specimen (JJG1250) is a peridotitic garnet with diamond and the last one remaining to be described (JJG1245) consists of a diamond embedded in a cluster of mica crystals.

The mineral compositions are given in Table I.

Nineteen of the twenty eclogitic garnets form a coherent main grouping in terms of chemical composition. The major variations can be expressed in terms of a negative correlation between calcium and magnesium within a narrow band of relatively constant iron contents. Similar garnets have been noted in diamond eclogites from Roberts Victor and the Crown Mine which like Star are north and east of Kimberley. Similar garnet compositions have also been reported in non-diamond bearing eclogite xenoliths at Premier Mine.

The field defined by the main Star grouping is outside the field of compositions of eclogitic garnets found in diamonds world-wide. It is also different to the fields defined by garnets in diamond eclogite from kimberlites in the Barkly West area, from Orapa, Botswana and particularly from Mir, U.S.S.R.

The single iron rich garnet in the sample suite described here (JJG1251) is well separated from the other garnets in the main trend and does fall within the diamond inclusion field.

All the eclogitic garnets have detectable sodium (up to 0.10 wt % Na_2O) and although titanium is lower than usual for diamond eclogite there is a linear (1:1)

Table I. Diamondiferous Minerals from Star Mine

Sample No	1232	1233	1234	1235	1236	1237	1238	1239
Oxide. Wt %	Gar.	Gar.	Gar.	Gar.	Gar.	Gar.	Gar.	Gar.
SiO_2	42.0	41.0	41.4	41.0	41.3	41.4	41.4	40.7
TiO_2	0.10	0.09	0.08	0.07	0.08	0.06	0.06	0.14
Al_2O_3	24.1	23.6	23.8	23.8	23.9	23.7	23.6	23.3
Cr_2O_3	0.09	0.10	0.11	0.08	0.08	0.11	0.11	0.01
FeO	9.86	7.80	8.98	6.77	8.41	9.50	7.41	10.6
MnO	0.19	0.18	0.17	0.12	0.17	0.18	0.13	0.17
MgO	18.4	12.7	14.8	13.7	14.6	16.6	14.7	12.5
CaO	6.56	15.3	11.6	14.8	12.6	8.68	12.4	13.2
Na_2O	0.06	0.09	0.06	0.08	0.05	0.04	0.06	0.09
K_2O	ND	ND	ND	ND	ND	ND	ND	ND
P_2O_5	0.04	0.11	0.03	0.03	0.05	0.03	0.04	0.09
Total	101.4	101.0	101.0	100.4	101.2	100.3	99.9	100.8

Sample No	1240	1241	1242	1243	1244	1245	1246	1247
Oxide. Wt %	Gar.	Gar.	Gar.	Gar.	Gar.	Phlog	Gar.	Gar.
SiO_2	40.9	41.1	41.2	41.1	40.7	39.5	41.1	41.1
TiO_2	0.11	0.08	0.07	0.06	0.10	0.85	0.07	0.08
Al_2O_3	23.3	23.7	23.9	23.9	23.5	16.2	24.0	23.6
Cr_2O_3	0.03	0.03	0.07	0.08	0.13	0.36	0.05	0.07
FeO	7.53	9.36	9.89	7.71	8.27	3.97	10.4	8.31
MnO	0.14	0.18	0.23	0.13	0.18	0.04	0.19	0.18
MgO	12.4	14.1	17.6	12.3	14.6	24.3	16.0	15.0
CaO	15.1	11.5	6.46	15.7	12.1	0.03	9.07	12.3
Na_2O	0.04	0.08	0.06	0.10	0.06	0.19	0.08	0.07
K_2O	ND	ND	ND	ND	ND	10.5	ND	ND
P_2O_5	ND	0.08	0.08	0.18	0.08	ND	0.10	ND
Total	99.5	100.2	99.6	101.2	99.7	95.9	101.1	100.7

Sample No	1248	1248	1249	1250	1251	1252	1253
Oxide. Wt %	Gar.	Cpx.	Gar.	Gar.	Gar.	Gar.	Gar.
SiO_2	41.5	56.2	41.7	42.3	40.9	41.6	40.8
TiO_2	0.13	0.14	0.08	0.02	0.04	0.08	0.08
Al_2O_3	23.7	11.8	23.4	21.6	23.2	23.2	23.4
Cr_2O_3	0.04	0.05	0.05	3.48	0.29	0.05	0.08
FeO	9.86	1.86	10.2	6.61	15.8	8.91	7.47
MnO	0.16	0.01	0.22	0.26	0.26	0.17	0.13
MgO	14.1	10.4	15.3	20.8	16.2	14.4	12.5
CaO	11.6	14.2	8.54	5.06	3.70	11.6	15.8
Na_2O	0.08	6.41	0.13	ND	0.09	0.05	0.06
K_2O	ND	0.02	ND	ND	ND	ND	ND
P_2O_5	0.08	ND	0.02	0.02	0.02	0.04	0.06
Total	101.2	101.1	99.6	100.2	100.5	100.1	100.4

relationship between (Ti + P) and Na. In addition none of the garnets have excess silica therefore the trace levels of sodium in the garnets cannot be attributed to pyroxene solid solution as was the case for inclusions in diamonds from the nearby Monastery Mine.

CONCLUSIONS

The co-existing gar-cpx pair in sample JJG1248 gives an apparent equilibration temperature of 1100°C (EG79, 50 kb).

The single peridotitic garnet with diamonds (JJG1250) has a composition which suggests it is derived from disaggregated garnet lherzolite. In southern Africa diamondiferous garnet lherzolite has been described from Mothae and Finsch by others.

The origin of the phlogopite - diamond sample JJG1245 is not clear. However phlogopite is a rarely reported inclusion in diamond so it is possible that the association is primary.

The kimberlite at Star contains macrocrysts of garnet and fragments of eclogite with garnets which have the same compositions as the garnets with the diamonds listed in Table I. This suggests that disaggregation of eclogite is a common source of diamonds in the intrusion. However since most of the specimens described here have well developed kelyphite rinds on their rounded outer surfaces it is clear that the break up of the xenoliths occurs during or prior to emplacement of the kimberlite and is not related to the mining process. Sub-calcic G10 garnets and chromites with >62.5 wt % Cr_2O_3 are also found in the Star kimberlite. Their presence is usually diagnostic of the peridotitic diamond paragenesis. Several sets of observations therefore suggest the presence of both eclogitic and peridotitic diamonds at Star as has been reported at many other localities. It is not possible to define the relative importance of the two parageneses but the finding of twenty samples of diamondiferous eclogitic minerals suggests that disaggregation of eclogite provides an important component of the diamonds at this locality. In this respect it adds to a growing list of localities which are emphasising the importance of eclogite as a diamond source. (Orapa, Premier, Monastery, Bellsbank, Dokolwayo and Sloan).

The differences in compositions noted between most of the garnets described here and eclogitic garnet inclusions in diamonds world-wide is attributed to re-equilibration of the xenocrysts post-diamond crystallisation, and to the armouring effects of the host diamond in respect of the inclusions.

The regional trends in composition of xenocrystal and xenolithic eclogitic garnets noted earlier suggest that the diamondiferous eclogite bodies sampled by the kimberlites have had different post-diamond crystallisation histories.