MINERAL INCLUSIONS IN DIAMONDS FROM JAGERSFONTEIN MINE.

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A total of 33 inclusions have been recovered from 28 diamonds from the now defunct Jagersfontein mine. Despite the small suite of minerals studied, the results are noteworthy because of the high proportion of unusual features exhibited within the standard world-wide framework that both eclogitic and peridotitic diamond inclusions have been found.

The peridotitic suite is represented by chromites, garnets and olivines. The eclogitic suite minerals found were garnets, clinopyroxenes and coesite, whilst orthopyroxene was also recorded in a websteritic association geochemically linked to the eclogitic parageneses as previously described at Monastery and Orapa.

In the peridotitic suite, 4 chromites have Cr_2O_3 contents ranging from 61 to 64.2 wt%, 3 sub-calcic garnets fit in the G10 field. One of these (J6a) is unusual in having only 2.51 wt% Cr_2O_3. Completing the suite are 3 olivines with Fo contents in the range 91-92. They are unusual in having high Cr and Ca contents. A fourth olivine (J15a) has a Fo content of 78.8, outside the peridotitic range and is only matched in mantle rocks by olivines in garnet websterites, such as those reported from Matsoku, Lesotho. J15a also has Fo equivalents in megacryst suite olivines. A websterite association is also proved by two orthopyroxene inclusions (J14a,J22a) which occur in two three phase polymineralic inclusions together with garnet and clinopyroxene. Both orthopyroxenes are enriched in FeO and CaO and have low Mg/Mg+Fe. The Clinopyroxenes are low in Al_2O_3 and Na_2O compared to those from the eclogitic suite. A third clinoproxene inclusion (J10a) has a similar composition and is also included in the websteritic association. The garnets have TiO_2 levels of .6 wt%, Cr_2O_3 of 1.4 wt% and 1.08 wt%, and Na_2O levels of .08 wt% and .14 wt%, making them more enriched in these elements than similar inclusions from Monastery and Orapa.

The pyroxene solid solution in garnet first noted at Monastery Mine (Moore 1986) and interpreted to reflect a particularly high crystallisation pressure, has been found to be common in Jagersfontein diamonds, certainly occurring in garnets in seven diamonds in the suite studied. One of these diamonds, (J22) contains a websteritic assemblage gar-cpx-opx in addition to $(gar\text{-}px)_{ss}$. The websteritic assemblage gives calculated equilibration conditions of 1272°C at 49.5kb. (using Lindsley and Dixon 1976 and Nickel and Green 1985), whilst the $(gar\text{-}px)_{ss}$. indicates pressures > 145kb. The other six garnet/clinopyroxene solid solutions give a pressure range of 100 to 145kb which suggests that at least some of the diamonds from Jagersfontein have formed in the depth interval from 150km to in excess of 450km. The same range was implied at Monastery (Moore 1986) and Brazil (Wilding and Harte, 1989). A second websteritic assemblage in (J14) gives similar calculated equilibration conditions, whilst an eclogitic gar-cpx pair in diamond (J37) equilibrated at 1295°C at an assumed pressure of 50kb according to the method of Ellis and Green (1979). These are within the diamond stability field.

The remaining minerals coesite (J13a) which co-existed with a garnet (J13b), and a garnet clinopyroxene co-existing pair (J37) are clearly eclogitic. The calculated equilibration temperature for J37 is 1295°C using the method of Ellis and Green (1979), and assuming all iron is present as Fe^{2+}, and a pressure of 50kb. Again this is within the diamond stability field and in reasonable agreement with the calculated temperatures of the websteritic association, which suggest that they were formed under similar temperature/pressure conditions.

It is inferred from this small suite of mineral inclusions from Jagersfontein diamonds that a probably incomplete inventory of diamond source rocks includes garnet and or chromite harzburgite, iron-rich eclogite, garnet websterite, majorite and rare coesite eclogite. Eclogite xenoliths with diamond have been reported from Jagersfontein previously. Majorite could be the protolith for rare mantle assemblages recently described by Haggerty and Sautter (1990). Sub-calcic peridotitic (G10) garnets and high Cr_2O_3 chromites, presumably derived from disaggregated diamond harzburgite are present as macrocrysts in the Jagersfontein kimberlite. The websterites and coesite eclogite have not been reported as xenoliths.

The overwhelming majority of peridotitic xenoliths described by others from the Jagersfontein kimberlite are not suitable diamond source rocks and have distinctly different mineral compositions compared to the inclusions in the diamonds. This situation pertains to all other similarly studied localities in southern Africa.

The low proportion of peridotitic inclusions in Jagersfontein diamonds contrasts with their abundance at Koffiefontein, 55km to the NNW.

References

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TABLE 1: Inclusions in Jagersfontein Mine Diamonds.

	J1a Chr	J2a Chr	J3a Chr	J4a Chr	J6a Gar	J7a Gar	J8a Gar	J10a Cpx	J11a Gar	J12a Olv
SiO_2	n.d.	n.d.	n.d.	n.d.	42.43	41.83	41.56	55.16	41.32	40.78
TiO_2	n.d.	.14	.07	.02	n.d.	.02	.03	.11	.13	n.d
Al_2O_3	7.08	7.40	9.50	4.20	22.37	15.36	18.07	1.15	22.76	.02
Cr_2O_3	63.27	62.35	60.96	64.18	2.51	11.98	8.03	.15	.17	.06
FeO	13.78	14.61	13.46	17.90	5.57	4.59	6.11	5.53	12.80	7.14
MnO	.79	.82	.79	.90	.24	.36	.34	.04	.41	.11
MgO	14.36	13.70	14.93	11.93	23.23	24.85	22.72	19.37	15.78	51.08
CaO					3.08	.98	2.31	16.74	6.36	.06
Na_2O								1.06	.10	
K_2O								.03		
NiO										.43
Total	99.29	99.02	99.13	99.13	99.43	99.97	99.17	99.34	99.83	99.68

	J13a Coes	J13b Gar	J14a Gar	J14a Cpx	J14a Opx	J15a Olv	J17a Cpx	J19a Olv	J21a Olv	J22a Gar
SiO_2	98.78	42.14	41.47	54.41	56.32	38.52	55.45	40.39	41.07	40.92
TiO_2	.05	.16	.60	.14	.11	.02	n.d.	n.d.	n.d.	.57
Al_2O_3	.09	20.90	21.10	1.36	.76	.02	.66	n.d.	.03	20.40
Cr_2O_3		.26	1.40	.24	.10	.02	.08	.06	.08	1.08
FeO	.20	13.37	13.03	6.82	10.88	19.48	3.62	8.25	8.03	13.75
MnO		.39	.41	.20	.17	.19	.08	.10	.09	.39
MgO		16.07	17.15	18.84	30.77	40.68	18.32	49.64	50.05	17.37
CaO	.11	6.07	5.04	17.14	1.31	.11	20.85	.07	.09	4.71
Na_2O		.25	.07	.90	.15		1.04			.14
K_2O							n.d.			
NiO								.35	.38	
Total	99.23	99.61	100.26	100.03	100.56	99.04	100.10	98.86	99.82	99.33

	J22a Cpx	J22a Opx	J22b $(Gar\text{-}px)_{ss}$	J23a $(Gar\text{-}px)_{ss}$	J24a Gar	J25a $(Gar\text{-}px)_{ss}$	J26a Gar	J26b Gar	J27a $(Gar\text{-}px)_{ss}$	J28a Gar
SiO_2	54.16	55.95	47.94	46.17	41.15	42.96	40.49	40.19	44.79	41.52
TiO_2	.12	.08	.67	.23	.90	.19	.42	.44	.23	.56
Al_2O_3	1.65	.71	8.82	15.95	19.83	19.34	22.47	21.99	16.69	21.84
Cr_2O_3	.27	.06	.55	.28	2.23	.20	.08	.08	.22	.53
FeO	7.08	10.29	13.75	11.05	13.22	13.00	15.25	15.45	12.82	11.91
MnO	.15	.17	.30	.27	.42	.43	.30	.31	.35	.26
MgO	18.35	31.28	22.08	19.25	16.94	15.91	12.41	13.09	18.86	18.95
CaO	16.37	1.17	5.52	5.91	5.43	7.94	8.28	8.48	6.05	3.79
Na_2O	1.43	.29	.33	.69	.04	.26	.14	.14	.29	.08
K_2O	n.d.	n.d.								
NiO										
Total	99.58	99.99	99.96	99.80	100.16	100.23	99.84	100.17	100.30	99.44

	J29a $(Gar\text{-}px)_{ss}$	J31a $(Gar\text{-}px)_{ss}$	J32a $(Gar\text{-}px)_{ss}$	J34a Cpx	J35a Cpx	J37a Cpx	J37b Gar
SiO_2	45.89	42.84	47.29	54.06	54.27	54.81	40.99
TiO_2	.22	.10	.19	.61	.55	.60	.70
Al_2O_3	17.27	21.46	14.09	6.52	8.67	6.84	22.94
Cr_2O_3	.41	.11	.21	n.d.	.02	.18	.18
FeO	10.26	13.49	11.00	13.47	9.16	5.52	13.03
MnO	.25	.33	.29	.12	.09	.11	.31
MgO	19.60	15.90	19.35	8.09	8.62	13.82	16.62
CaO	5.24	6.10	7.03	13.77	13.91	13.94	4.71
Na_2O	.44	.12	.54	3.77	4.54	4.00	.24
K_2O				.05	.04	.24	
NiO							
Total	99.58	100.45	99.99	100.46	99.87	100.06	99.72

n.d. = not detected

Mineral compositions obtained on a Cameca Camebax Microbeam electron microprobe, using close standards and a ZAF correction proceedure.

J14a & J22a are single inclusions of Gar-Cpx-Opx minerals touching each other.