GEOTHERMOBAROMETRY OF DIAMOND INCLUSIONS FROM THE DE BEERS POOL MINES, KIMBERLEY, SOUTH AFRICA.

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One of the most important methods for ascertaining the chemical environment of diamond genesis remains the study of syngenetic inclusions in diamonds. In some cases diamonds contain inclusions of different mineralogies, that can provide information on temperatures and pressures of the diamond-forming event (cf. Harris, 1992). In the present study, 547 inclusion-bearing diamonds from the De Beers Pool mines were examined. The De Beers Pool mines include the Wesselton, Bultfontein, De Beers and Du Toitspan kimberlites. As these mines are due to close in the near future, the current investigation represents the last opportunity for obtaining a large sample of inclusion-bearing diamonds from this historically and geologically important locality. While the De Beers Pool kimberlites are Cretaceous in age, inclusions in harzburgitic diamond appear to be Archaean with Sm/Nd model ages of ~ 3.3 Ga (Richardson et al., 1984).

During inclusion break-out, emphasis was placed on the recovery of minerals suitable for geothermobarometry. The De Beers Pool inclusion suite is unusual in that it contains a high proportion of polymineralic (touching minerals) inclusions. In all, 42 polymineralic and 21 co-existing, monomineralic, inclusion assemblages were recovered (Table 1).

The most common bimineralic (touching) peridotitic inclusions are garnet+orthopyroxene and chromite+olivine pairs. Less abundant (touching) combinations include garnet+olivine, garnet+sulphide and chromite+orthopyroxene. Trimineralic (touching) peridotitic inclusions comprise garnet+orthopyroxene+chromite, garnet+orthopyroxene+olivine and garnet+olivine+magnesite assemblages. Only two polymineralic eclogitic inclusions were recovered, consisting of garnet+clinopyroxene and garnet+clinopyroxene+rutile combinations.

Monomineralic inclusion pairs (non-touching) include garnet+orthopyroxene, garnet+olivine, chromite+olivine, orthopyroxene+olivine and garnet+clinopyroxene (lherzolitic and eclogitic parageneses) assemblages.

Geothermobarometric estimates were obtained from 32 polymineralic and 17 monomineralic inclusion pairs, using the thermometer/barometer combinations of Harley (1984), O'Neill and wood (1979, 1980), Krogh (1989) and Brey and Köhler (1990) (Figure 1). With one or two exceptions, the polymineralic and monomineralic inclusion groups exhibit distinct temperatures and pressures. The polymineralic garnet-orthopyroxene combinations yield temperatures of 1003°C - 1176°C and pressures of 42 - 65kb, with mean values of 1072°C and 53kb, respectively. The monomineralic garnet-orthopyroxene pairs give temperatures of 1052 - 1314°C and pressures of 46 -

105kb, with mean values of 1207°C and 65kb, respectively. Garnet-olivine and garnet-clinopyroxene assemblages give similar temperatures, assuming 50kb for polymineralic and 60kb for monomineralic inclusions. Overall the polymineralic inclusions have mean temperatures and pressures of 1072°C and 53kb, while the monomineralic inclusions are characterised by values of 1217°C and 65kb, respectively. Thus, differences in mean values between the two groups of inclusions are 155°C and 8 kb. The temperature difference is maintained even if all inclusion pairs are assigned the same pressure (e.g. 50kb) or if versions of the MacGregor (1974) geobarometer are used instead of the Brey and Köhler (1990) option.

It is concluded from the above data that diamond formation and inclusion encapsulation took place at temperatures between 1150°C and 1350°C, as recorded by the monomineralic inclusion pairs. These inclusions were armoured by the diamond and were unable to respond to thermobarometric changes in the surrounding mantle. By contrast, the polymineralic inclusions were able to re-equilibrate in response to external conditions and record a decrease in temperatures since diamond formation. The latter temperatures (and pressures) are analogous to those recorded from coarse mantle xenoliths from the De Beers Pool kimberlites (e.g. Boyd, 1978). The apparent pressure differences between the poly- and monomineralic inclusions could represent either an artefact of the geobarometer, which is highly temperature-sensitive, or differential movement in the mantle subsequent to diamond crystallisation.

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TABLE 1 : Abundance table of co-existing (touching and non-touching) inclusions extracted from De Beers Pool diamonds

INCLUSION ASEMBLAGES	POLYMINERALIC INCLUSIONS	MONOMINERALIC INCLUSIONS
PERIDOTITIC		
Garnet+Orthopyroxene	21	8
Garnet+Olivine	2	2
Garnet+Sulphide	1	0
Garnet+Clinopyroxene	0	1
Garnet+Orthopyroxene+Spinel	3	0
Garnet+Orthopyroxene+Olivine	3	0
Garnet+Olivine+Magnesite	1	0
Chromite+Orthopyroxene	2	0
Chromite+Olivine	7	2
Orthopyroxene+Olivine	0	1
ECLOGITIC		
Garnet+Clinopyroxene	1	7
Garnet+Clinopyroxene+Rutile	1	0

FIGURE 1: Temperature versus pressure plot for co-existing inclusions from De Beers Pool diamonds. The diamond-graphite univariant reaction curve of Kennedy and Kennedy (1976) and the 40mW/m^2 cratonic geotherm of Pollack and Chapman (1977) are also shown.