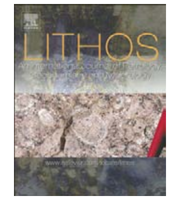
Lithos 112S (2009) 852–864

Contents lists available at ScienceDirect

Lithos

journal homepage: www.elsevier.com/locate/lithos



A mantle origin for Paleoarchean peridotitic diamonds from the Panda kimberlite, Slave Craton: Evidence from ^{13}C-, ^{15}N- and $^{33,34}S$-stable isotope systematics

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ARTICLE INFO

Article history:
Received 30 September 2008
Accepted 3 June 2009
Available online 23 June 2009

Keywords:
Mantle
Stable isotopes
Diamond
Continental lithosphere

ABSTRACT

In order to address diamond formation and origin in the lithospheric mantle underlying the Central Slave Craton, we report N- and C-stable isotopic compositions and N-contents and aggregation states for 85 diamonds of known paragenesis (73 peridotitic, 8 eclogitic and 4 from lower mantle) from the Panda kimberlite (Ekati Mine, Lac de Gras Area, Canada). For 12 peridotitic and two eclogitic sulfide inclusion-bearing diamonds from this sample set, we also report multiple-sulfur isotope ratios.

The 73 peridotitic diamonds have a mean $\delta^{13}C$-value of −5.2‰ and range from −6.9 to −3.0‰, with one extreme value at −14.1‰. The associated $\delta^{15}N$-values range from −17.0 to +8.5‰ with a mean value of −4.0‰. N-contents range from 0 to 1280 ppm. The 8 eclogitic diamonds have $\delta^{13}C$-values ranging from −11.2 to −4.4‰ with one extreme value at −19.4‰. Their $\delta^{15}N$ ranges from −2.1 to +7.9‰ and N-contents fall between 0 and 3452 ppm. Four diamonds with an inferred lower mantle origin are all Type II (i.e. nitrogen-free) and have a narrow range of $\delta^{13}C$ values, between −4.5 and −3.5‰. The $\delta^{34}S$ of the 14 analyzed peridotitic and eclogitic sulfide inclusions ranges from −3.5 to +5.7‰. None of them provide evidence for anomalous $\delta^{33}S$-values; observed variations in $\delta^{33}S$ are from +0.19 to −0.33‰, i.e. within the 2 sigma uncertainties of mantle sulfur ($\delta^{33}S = 0$‰).

At Panda, the N contents and the $\delta^{13}C$ of sulfide-bearing peridotitic diamonds show narrower ranges than silicate-bearing peridotitic diamonds. This evidence supports the earlier suggestion established from eclogitic diamonds from the Kaapvaal that sulfide-(±silicate) bearing diamonds sample a more restricted portion of sublithospheric mantle than silicate-(no sulfide) bearing diamonds. Our findings at Panda suggest that sulfide-bearing diamonds should be considered as a specific diamond population on a global-scale. Based on our study of $\delta^{34}S$, $\Delta^{33}S$, $\delta^{15}N$ and $\delta^{13}C$, we find no evidence for subduction-related isotopic signatures in the mantle sampled by Panda diamonds.

1. Introduction

Within the last 30 years, using evidence from the study of deep-seated xenoliths and diamonds from southern African kimberlites, numerous models have been proposed to describe the formation and origin of the continental cratonic lithosphere (e.g. Boyd and Gurney, 1986; Haggerty, 1986; Pearson and Wittig, 2008). The discovery and mining of diamondiferous kimberlites on the Northern (Jericho), Central (Ekati, DO-27, Diavik) and southern Slave Craton (Snap Lake) provides new opportunities to test and refine these models.

In the last few years, several first order distinctions between the subcratonic lithospheric mantle beneath the Slave and Kaapvaal Cratons have been made. Diamonds from the Slave are less resorbed than their South African counterparts (Stachel et al., 2003; Gurney et al., 2004) and, in this respect, are more similar to Siberian diamonds. Diamonds from the Slave also include a higher proportion of coated stones (commonly referred to as *fibrous* diamonds although this represents a simplification since some coats can actually be well-crystallised and non-fibrous diamond, c.f. Moore, 1985). Eclogite xenoliths from the Slave (Jericho and Diavik) have been dated to ~2.1 Ga (Paleoproterozoic) (Schmidberger et al., 2005, 2007) and thus are generally younger than eclogite xenoliths from the Kaapvaal (and Yakutia) which are principally Archean in age (see Pearson et al., 1995a,b). In contrast, the formation of peridotitic lithospheric mantle components in the Central Slave extends

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doi:10.1016/j.lithos.2009.06.007

Table 1
$\delta^{13}C$, $\delta^{15}N$, N contents (determined by infrared spectroscopy and/or bulk combustion) and percentage of the nitrogen B species, averaged $\delta^{34}S$ and $\Delta^{33}S$ of sulfides in diamonds from Panda.

Sample paragenesis			Weight	$\delta^{13}C$	$\delta^{15}N$	−	+	N_{COMB}	N_{COMB}	N_{FTIR}	B	$\delta^{34}S$	$\Delta^{33}S$
			(mg)	(‰)	(‰)			(ppm)	(at.ppm)	(at.ppm)	(%)	(‰)	(‰)
PA01	p	H	2.3437	−5.58	0.9	−0.6	0.6	451	387	348	22		
PA02	p	H	3.0041	−5.22	1.2	−0.5	0.5	826	708	372	11		
PA03	p	H	1.7632	−4.58						0			
PA04	p	H	1.7632	−4.58						0			
PA05	p	H	2.2344	−5.81	5.7	−0.6	0.8	267	229	225	19		
PA06	p	H	2.3977	−5.51						26	3		
PA07	p	H	0.7387	−5.21						67	47		
PA08	p	H	0.6741	−5.19						0			
PA09	p	H	2.7824	−5.28	−4.1	−0.6	0.5	744	638	631	89		
PA10	p	H	1.3059	−5.65	1.2	−0.8	0.9	116	99	125	56		
PA11	p	L	0.5774	−5.32	−10.8	−1.0	0.5	550	471	345	80		
PA12	p	H	1.1805	−5.05						12			
PA13	p	H	2.7696	−5.07	1.2	−0.8	0.9	50	43	56	40		
PA14	p	H	2.9360	−6.93	−1.5	−0.6	0.5	498	427	296	41		
PA15	p	H	1.5258	−14.05						0			
PA16	p	H	0.9322	−5.00	−15.8	−2.4	0.1	96	82	131	61		
PA17	p	H	1.5453	−5.45						17	0		
PA18	p	H	0.4054	−4.99						106	71		
PA19	p	L	1.0909	−5.71	3.4	−0.7	1.0	127	109	65	47		
PA20	p	H	0.7688	−5.01	−15.4	−1.4	0.3	253	217	118	62		
PA21	p	H	1.5788	−5.50	−0.9	−1.0	0.9	91	78	73	51		
PA22	p	H	1.4411	−4.27	−17.0	−1.0	0.4	183	157	192	79		
PA23	p	L	3.2667	−4.85	2.4	−0.5	0.5	680	583	543	57		
PA24	p		3.2115	−3.58		−0.5	0.5	577	495	464	7		
PA25	p		3.7332	−5.73	−6.4	−0.6	0.5	467	400	544	85		
PA26	p		1.2280	−5.14	−5.1	−0.8	0.6	245	210	269	11		
PA27	p		1.7429	−4.33						27	0		
PA28	p		1.7695	−4.98	−7.5	−1.2	0.6	90	77	174	6		
PA29	p		0.9011	−5.32	−10.8	−0.9	0.5	267	229	292	0		
PA30	p		1.2522	−4.77	−6.3	−0.7	0.6	375	321	78	9		
PA31	p		3.9765	−5.05	−6.9	−0.6	0.5	228	195	237	8		
PA32	p		1.1208	−2.98						148	2		
PA33	p		1.1550	−4.87	−3.5	−0.8	0.7	248	213	74	0		
PA34	p		0.9944	−5.31	−7.7	−1.0	0.6	226	194	271	13		
PA35	p		1.2376	−5.07	−6.8	−1.1	0.6	155	133	184	14		
PA36	p		0.8947	−4.73	−0.2	−0.6	0.6	1280	1097	609	8		
PA37	p		2.0017	−5.96	3.0	−0.6	0.7	135	116	79	45		
PA38	p		1.1500	−4.34	0.2	−0.6	0.6	572	490	404	26		
PA39	lm ?		1.4933	−3.55						0			
PA40	p	L	2.5249	−5.75						0			
PA41	p		1.7900	−5.12	−4.0	−0.7	0.6	223	191	55	62		
PA42	p	H	3.0033	−4.86	−14.5	−0.6	0.5	532	456	333	81		
PA43	p		1.3835	−5.15	−3.1	−0.7	0.6	330	283	118	37		
PA44	unk		1.6425	−5.74	3.8	−1.0	1.6	105	90	57	34		
PA45	p		2.3526	−4.87	8.5	−0.5	1.1	87	75	70	40		
PA46	p		2.4770	−5.71	3.8	−0.7	0.9	104	89	57	49		
PA47	p		1.2538	−4.27	0.4	−0.6	0.6	1072	919	782	7		
PA48	p		1.3928	−5.03	1.3	−0.6	0.6	995	853	834	22		
PA49	p		1.1653	−5.45	−1.8	−1.2	1.0	93	80	494	85		
PA50	lm ?		1.3593	−4.01									
PA51	p		2.8825	−5.57	1.3	−0.6	0.6	745	639	608	7.4		
PA52	p		0.7370	−5.71	0.7	−0.6	0.6	581	498	341	46		
PA53	unk		3.3445	−5.79									
PA54	lm ?		0.8656	−3.50									
PA55	lm ?		1.1777	−5.27							13		
PA56	p		0.6544	−6.36	−3.2	−0.6	0.6	1124	963	859	92		
PA57	p	S	1.1167	−4.96	−1.1	−0.6	0.6	487	417	338	13	1.2	0.15
PA58	p	H	0.9998	−5.40	−0.8	−0.6	0.6	386	331	72	52		
PA59	p	L	2.5684	−4.42						0			
PA60	p	L	1.9878	−6.10	3.5	−0.5	0.5	1074	921	620	86		
PA61	p	L	3.3804	−4.46						0			
PA62	p	L	1.4952	−4.56						0			
PA63	e		0.9902	−11.21						0			
PA64	e		1.9441	−5.10	−2.1	−0.5	0.5	823	705	648	3		
PA65	e		0.9823	−19.40	7.9	−0.5	0.5	3452	2959	2720	100		
PA66	e	S	0.8847	−9.90	2.5	−0.6	0.7	741	635	638	69	2.3	0.15
PA67	p	L	0.8318	−4.59	−2.4	−1.0	0.8	227	195	184	100		
PA68	p	L	0.5623	−5.59		−1.2	1.2	275	236	262	100		
PA69	p	L	1.4254	−5.29	−2.5	−0.6	0.6	1114	955	1028	14		
PA70	p	L	0.2135	−5.07				184	158	64	11		
PA71	e	S	1.1519	−8.36						14	0		
PA72	unk		1.0974	−4.46						0			

(continued on next page)