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Re-evaluation of the composition of sediments from the Murray Darling Basin of Australia as a Potential Source Area for airborne dust to EPICA Dome C in Antarctica. Reply to Comment on "Lead isotopic evidence for an Australian source of aeolian dust to Antarctica at times over the last 170,000 years" by P. De Deckker, M. Norman, I.D. Goodwin, A. Wain and F.X. Gingele [Palaeogeography, Palaeoclimatology, Palaeoecology 285 (2010) 205–223]

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ABSTRACT

We re-examined the data presented by De Deckker et al. (2010; Lead isotopic evidence for an Australian source of aeolian dust to Antarctica at times over the last 170, 000 years. Palaeogeography, Palaeoclimatology, Palaeoecology 285, 205–223), which argued for some parts of the Murray Darling Basin (MDB) in south-eastern Australia to have been potential source areas (PSA) for dust in the EPICA Dome C ice core. This was done in light of the comments tabled by Kamber et al. (Comment on "Lead isotopic evidence for an Australian source of aeolian dust to Antarctica at times over the last 170,000 years" by P. De Deckker, M. Norman, I.D. Goodwin, A. Wain and F.X. Gingele [Palaeogeography, Palaeoclimatology, Palaeoecology 285 (2010) 205–223], 2010-this issue) suggesting that the MDB samples are variably contaminated by anthropogenically-produced Pb that originated from the Broken Hill mine, from smelters, and from agricultural practices and coal burning. We argue, first of all, that the MDB samples are not as comprehensively contaminated with Pb as claimed by Kamber et al., and the Pb isotope data presented by De Deckker et al. (2010) do provide useful information about potential dust source. Following the approach of Kamber and colleagues (Marx et al., 2010), we compare the Pb isotopic compositions of MDB sediments against their Pb content and diagnostic elemental ratios such as Pb/Ta, and Pb/Ga to evaluate possible anthropogenic contamination. We find that 3 of these MDB samples have notably high Pb concentrations, anomalously high Pb/Ta and Pb/Ga ratios, and Pb isotopic compositions that are consistent with anthropogenic contamination from a Broken Hill-type Pb source. The remaining 20 samples show a wide range of isotopic compositions and no correlation with either Pb content or element ratios, consistent with natural signatures. The 3 contaminated samples are located in heavily used agricultural areas in the Murray sub-basin but, importantly, none of these 3 samples were considered by De Deckker et al. (2010) to represent potential source areas for dust in the Dome C ice core. Secondly, previous studies have shown that significant Pb contamination in Australian surficial sediments tends to be localised, and that sub-surface samples can be used reliably for comparison with deposits that contain airborne dust.

Thirdly, we argue that valid evaluation of potential sedimentary dust sources can only be made on the same grain size fractions as those found in Antarctic ice cores, as it was recently demonstrated by Feng et al. (2010) and Vallelonga et al. (2010) that Pb isotopic ratios of aeolian deposits and Australian sediments vary with grain size. Our measurements were made on <2 μm fractions of MDB sediments, which are directly comparable to the particle size of ice core dust.

We, therefore, maintain that the Darling sub-basin represents a potentially significant source area for dust delivered to the Dome C site through time.

1. Introduction

Fingerprinting airborne dust and identifying its provenance is difficult. Efforts to understand the sources of dust within the regolith, dust transport mechanisms, and the compositional modification of

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dust both during transport and after deposition has led to a series of investigations that rely on the understanding of a variety of physico-chemical processes. Fingerprinting sediments requires a multidisciplinary approach involving handling and geochemical analysis of extremely small samples. This type of approach permits the "ice core research community" to extract minute amounts of aeolian dust from ice cores and determine its composition. A corollary of these investigations has been to determine the origin of this aeolian component. Until recently, the Australian continent had been excluded as a source of dust in Antarctic ice cores based primarily on Sr and Nd isotopic signatures (see Delmonte et al., 2004; Grousset et al., 1992). However, the sampling of potential Australian dust sources by these studies was very limited. Revel-Rolland et al. (2006) were the first to allude to the fact that the Lake Eyre region in central Australia (Fig. 1) was a potential source of Antarctic dust based on an expanded sampling of lacustrine and 'loessic' deposits, often referred to in Australia as 'parna', in known dust-producing regions. This idea was supported by the modelling by Li et al. (2008), which indicated the importance of Australia as a source of dust to Antarctica as well as the Pacific and Southern Oceans.

These studies were followed by additional work that established the major element (Marino et al. 2008), rare earth element (Gabrielli et al., 2010), and the Sr, Nd and Pb isotopic compositions (De Deckker et al. 2010; Gingele and De Deckker, 2005) of the clay fraction (≤ 2 μm) separated from some 30 fluvial samples of overflow deposits from various rivers and tributaries within the Murray Darling Basin [MDB] of eastern Australia (Fig. 1). The Murray system is located mostly in the temperate climate of south-eastern Australia, whereas the Darling and its tributaries drain semi-arid to arid terrains where wind erosion is common. De Deckker et al. (2010) proposed that the Darling sub-basin is a potential source of aeolian material to Antarctica, especially during interglacial periods, based primarily on Pb isotopic compositions and meteorological observations of atmospheric dust transport trajectories.

The use of Pb isotopic compositions to fingerprint dust sources is challenging. Vallelonga et al. (2002) identified a history of Pb pollution at Law Dome, located near the coast of Antarctica facing Australia. Their work dealt with an ice core in which they identified a four-fold enrichment in Pb concentration over the 2 decades AD 1884–1908 compared to background values for older ice, as well as Pb isotopic changes which they attributed to signatures of Broken Hill ore smelted either at Broken Hill or Port Pirie (see Fig. 1). The period of greatest anthropogenic inputs coincides to a large extent with an extremely long period of drought that affected Australia between 1895 and 1902 referred to as the 'Federation Drought'. A second period of anthropogenic contamination coincided with ~1960 to ~1980, attributed to emissions from alkyl-Pb additives in gasoline as well as coal burning and smelting (Vallelonga et al., 2002).

Pb isotopic values for pre-industrial ice core samples from EPICA Dome C and several regolith samples from south-central Australia were published by Vallelonga et al. (2005) and discussed in more detail by Vallelonga et al. (2010). They showed that Antarctic dust represents mixtures of locally-derived and exotic components, and concluded that southern South America was the predominant source of exotic dust despite the relative similarity of Australian and southern South American Potential Source Areas (=PSA) signatures

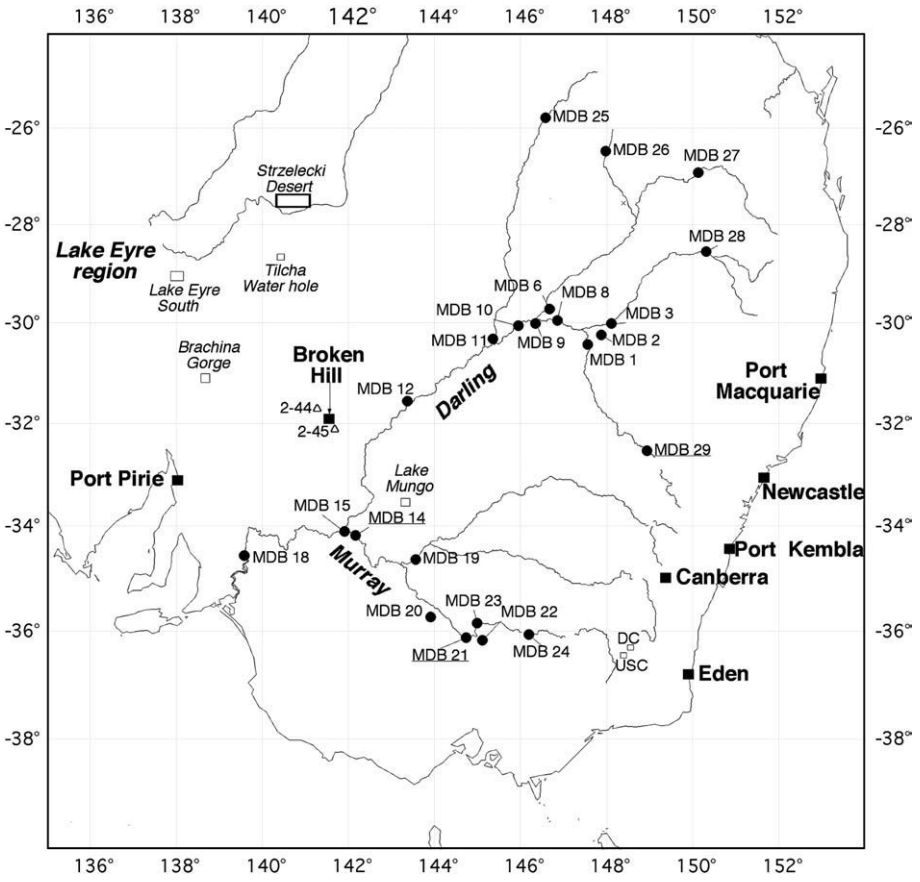

Fig. 1. Locality map showing all the samples and locations mentioned in the text. The MD prefix relates to all the samples discussed in De Deckker et al. (2010) paper. Two regolith samples taken in the vicinity of Broken Hill mine [2-44 and 2-45], UC and UDC refer to core sites from the two alpine peat bogs [Upper Snowy and Duck Creek] examined by Marx et al. (2010), Vallelonga et al. (2010)'s sites are also shown.

(Vallelonga et al., 2010). This conclusion was supported mainly by the wider range of Australian PSA Pb isotopic compositions, and the trend in these data away from the Antarctic mixing array.

In this issue, Kamber et al. (2010-this issue) question the utility of the Pb isotopic data presented by De Deckker et al. (2010), arguing that the MDB samples were "severely polluted" by anthropogenic Pb contamination, and that other potential dust sources need to be considered. In this Reply, we present a direct evaluation of anthropogenic contamination in the MDB sediment samples of De Deckker et al. (2010), and consider the importance of comparing the appropriate grain size fraction of a sediment with aeolian dust, and the process of deflation and dust transport over large distances. Our reply to those comments offers the opportunity to further detail our findings in light of additional investigations recently published, such as the geochemical investigations carried out by Marx et al. (2010) on two peat bog deposits located on the western side of the Snowy Mountains and on the south-eastern edge of the MDB from where De Deckker et al.'s (2010) samples were collected.

2. Discussion

2.1. Possible anthropogenic Pb contamination

The primary criticism levelled by Kamber et al. (2010-this issue) is that the MDB samples analysed by De Deckker et al. (2010) are all so severely contaminated by anthropogenic Pb that they cannot, under any circumstances, be used for comparison with pre-industrial dust records.

We address this issue by comparing trace element ratios that are diagnostic for anthropogenic Pb contamination with their Pb isotopic composition, as proposed previously by Kamber and colleagues (Marx et al., 2010), and by citing published studies demonstrating that anthropogenic Pb contamination in eastern Australian fluvial systems tends to be localised rather than pervasive.

Marx et al. (2010) presented evidence for post-industrial Pb pollution in 2 separate remote alpine sites in the Snowy Mountains, on the edge of the MDB. These 2 sites are peat bogs (Upper Snowy Core [=USC in Fig. 1] and Duck Creek [=DC in Fig. 1]) that convincingly show anthropogenically-contaminated Pb in the upper parts [<10 cm from the surface] of the peat cores. Their study also documents that, in addition to Pb contamination, other metals are also indicative of industrial pollution, which these authors argue could be the by-product of coal combustion, the use of fertilisers, ore smelting, or mining activities.

Of importance is that, in the contaminated upper peat layers, ratios of several elements relative to Pb contents correlate well with Pb isotopic ratios and seem to pinpoint the anthropogenic changes in the peat bogs. For example, Pb/Ga ratios are ~1 below the upper 10 cm [~1850 AD] in the USC core and then increase up to 5 near the top. Similarly, pre-industrial Pb/Ta values of ~20 increase to values >80 near the contaminated top of the core. In the DC core, Marx et al. (2010) show a value of ~0.5 for Pb/Ta below 30 cm [<250 years old] that increased up to 1.5 for younger layers. In both cases, the Pb/Ga and Pb/Ta ratios of pre-industrial sediments can be used to approximate natural compositions that preserve uncontaminated Pb isotopic compositions.

We have applied this approach to the MDB samples analysed by De Deckker et al. (2010) to see if a combination of Pb isotopes and trace element ratios such as Pb/Ga, Pb/La and Pb/Ta support Kamber et al.'s claim of pervasive Pb contamination. If that were true, then the Pb/Ga and Pb/Ta compositions should be elevated relative to the pre-industrial compositions proposed by Marx et al. (2010). As Ta values are not available for the MDB samples, we have converted the measured Pb/Nb values to equivalent Pb/Ta ratios (=Pb/Ta*) by assuming a value of Nb/Ta=12 for the continental crust (Barth et al., 2000). As shown in Figs. 2 and 3, all but three of the MDB samples have Pb/Ga and Pb/Ta* ratios that are centred about the range of pre-industrial eastern Australian dust as defined by the study of Marx et al. (2010), despite a wide range of Pb isotopic compositions (data in Table 1). Plots of similar ratios such as Pb/La versus Pb isotopes show the same trends (see data on Table 1). Note also that we calculated the average values and standard deviations for all of our samples, excluding the 3 samples [MD 14, 21 and 29] which we acknowledge are likely to be contaminated [see discussion below], and these values

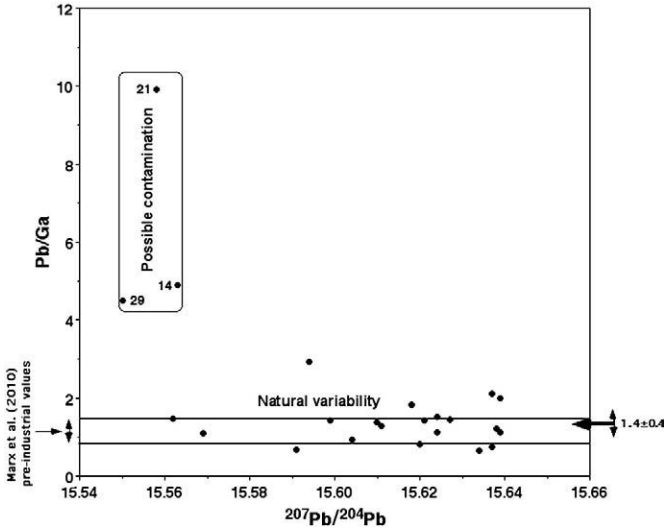

Fig. 2. Diagram showing Pb/Ga versus $^{207}Pb/^{204}Pb$ for the samples from the Murray Darling Basin. Three samples plot away from those considered to reflect natural variability, and are likely to be contaminated by anthropogenic sources. In the lower portion of the diagram, the 2 horizontal lines mark the range of Pb/Ga values (0.8–1.5) regarded by Marx et al. (2010) to represent pre-industrial dust in the alpine peat bog cores. The average values and standard deviations for Pb/Ga for all of our samples, excluding the 3 samples [MD 14, 21 and 29, which are underlined in Fig. 1] which we acknowledge are likely to be contaminated, appear next to the large horizontal arrow on the right of the diagram.

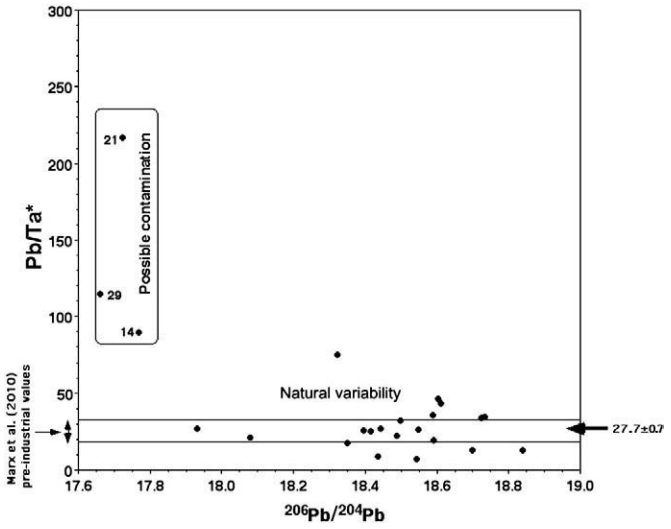

Fig. 3. Diagram showing *equivalent* Pb/Ta ratios versus $^{206}Pb/^{204}Pb$ for the samples from the Murray Darling Basin. Three samples plot away from those considered reflect natural variability, and which are likely to be contaminated by anthropogenic sources. The Pb/Ta* ratios were calculated by using Pb/Nb values, assuming a value of Nb/Ta=12 for the continental crust as calculated by Barth et al. (2000) [see text for additional information]. Pb/Ta* is plotted for comparison against Marx et al. (2010)'s data from the alpine peat bog cores shown by the 2 horizontal lines that delimit the pre-industrial values. The average values and standard deviations for Pb/Ta* for all of our samples, excluding the 3 samples [MD 14, 21 and 29] which we acknowledge are likely to be contaminated, appear next to the large horizontal arrow on the right of the diagram.

Table 1
Compilation of various elemental and Pb isotopic ratios from the Murray Darling Basin. Note that the Pb/Ta ratios [labeled here as Pb/Ta*] were calculated assuming a value of Nb/Ta=12 for the continental crust as calculated by Barth et al. (2000). See text for additional information. Trace elements were obtained by ICP-MS [refer to Gingele and De Deckker (2005) for further details].

Sample	Ga (ppm)	La (ppm)	Pb (ppm)	Nb (ppm)	River	M=Murray D=Darling	Latitude	Longitude	Pb/Nb	Nb/12 =equiv Ta	Pb/La	Pb/Ta•	Pb/Ga
MDB1	18.98	31.67	17.75	11.97	Macquarie	M	30°26.047' S	147°34.163' E	1.48	0.998	0.559	17.754	0.933
MDB2	21.47	35.90	14.16	23.77	Castlereagh	D	30°14.777' S	147°52.917' E	0.60	1.981	0.399	7.229	0.667
MDB3	18.98	26.82	13.00	12.95	Namoi	D	30°00.995' S	148°07.231' E	1.09	1.079	0.528	13.112	0.746
MDB6	17.84	28.91	19.98	10.94	Birrie	D	29°43.149' S	146°40.632' E	1.78	0.912	0.673	21.335	1.090
MDB8	20.89	33.88	23.35	14.63	Barwon	D	29°56.878' S	146°51.812' E	1.61	1.219	0.695	19.325	1.128
MDB9	24.06	40.29	30.93	14.74	Bogan	M	30°00.494' S	146°21.268' E	2.25	1.228	0.822	26.947	1.376
MDB10	20.75	33.34	29.09	14.24	Darling	D	30°03.409' S	145°57.064' E	2.09	1.187	0.893	25.079	1.434
MDB11	20.30	32.91	28.70	10.41	Warrego	D	30°19.092' S	145°21.571' E	2.84	0.868	0.898	34.052	1.455
MDB12	20.33	30.36	40.25	12.49	Darling	D	31°33.607' S	143°22.700' E	2.96	1.041	1.218	35.529	1.819
MDB14	18.42	22.97	92.51	12.10	Murray	M	34°10.943' S	142°10.338' E	7.45	1.008	3.924	89.395	4.894
MDB15	18.16	29.22	28.24	11.89	Darling	M	34°06.485' S	141°55.248' E	2.24	0.991	0.913	26.917	1.469
MDB18	17.53	27.36	23.92	12.21	Murray	M	34°34.044' S	139°35.673' E	1.84	1.018	0.823	22.123	1.284
MDB19	23.85	40.15	27.71	12.35	Murrumbidgee	M	34°38.791' S	143°33.944' E	2.16	1.029	0.663	25.875	1.117
MDB20	23.82	37.59	29.83	13.20	Loddon	M	35°44.101' S	143°54.623' E	2.20	1.100	0.772	26.382	1.218
MDB21	20.89	32.21	202.07	11.47	Campaspe	M	36°07.228' S	144°44.660' E	18.07	0.956	6.436	216.868	9.923
MDB22	25.74	37.28	40.53	14.57	Goulburn	M	36°10.574' S	145°07.113' E	2.68	1.214	1.049	32.211	1.519
MDB23	24.96	33.94	50.90	13.80	Murray	D	35°51.223' S	144°59.943' E	3.61	1.150	1.469	43.365	1.998
MDB24	26.38	38.28	56.40	14.55	Ovens	D	36°03.999' S	146°12.130' E	3.84	1.213	1.459	46.070	2.118
MDB25	21.29	33.42	34.02	10.57	Warrego	D	25°47.607' S	146°35.153' E	2.88	0.881	0.909	34.501	1.427
MDB26	18.84	30.12	57.00	8.79	Maranoa	D	26°29.121' S	147°58.84' E	6.27	0.733	1.830	75.263	2.926
MDB27	18.54	28.15	12.44	16.79	Condamine	D	26°55.596' S	150°07.907' E	0.75	1.399	0.448	9.020	0.681
MDB28	19.41	26.79	15.69	14.84	Macintyre	D	28°33.025' S	150°18.667' E	1.07	1.237	0.592	12.817	0.817
MDB29	21.68	50.54	99.34	10.17	Macquarie	M	32°32.55' S	148°56.535' E	9.59	0.848	1.929	115.021	4.496

are indicated in both Figs 2 and 3. These values fit in well within the range of values obtained by Marx et al. (2010).

The extent to which mixing of anthropogenic Pb can account for the range of Pb isotopic compositions in the MDB sediments can be further examined by plots of Pb isotopic composition vs. 1/Pb concentration, as binary mixing arrays on these types of plots are linear regardless of the compositions of the endmembers. Fig. 4 shows that there is no correlation between the Pb isotopic composition and the Pb content of the MDB samples having Pb/Ga and Pb/Ta ratios within the range of pre-industrial compositions defined by Marx et al. (2010), effectively disproving the hypothesis of Kamber et al. (2010-this issue) that the tight isotopic arrays within the MDB sediments reflects pervasive contamination with anthropogenic Pb.

We note further that Pb isotopic compositions of the majority of the MDB samples overlap with the uncontaminated samples shown on Kamber et al.'s Fig. 1 (although astutely obscured by the other data on this diagram), supporting our interpretation that these represent natural sediment compositions; these uncontaminated compositions were those specifically identified as likely source areas for Antarctic dust by De Deckker et al. (2010).

Three of the MDB samples do show significantly elevated values of Pb/Ga and Pb/Ta*, along with the lowest values of Pb isotopic compositions obtained in this set of samples (Figs. 2–4). These three samples also have elevated Pb contents (Fig. 4) confirming probable anthropogenic contamination in these samples. These three contaminated MDB samples (MD14 from the River Murray east of Mildura, MD21 on the Campaspe River, and MD29 on the southern end of the Macquarie River) are all from areas with considerable agricultural activities nearby.

The issue of Pb contamination in sediments is not a new one and several significant case studies have been performed in Australia to evaluate the level of post-industrial contamination of surficial sediments in the vicinity of industrial sites. For example, Lottermoser (1998) examined heavy metal concentrations in several rivers in north-eastern New South Wales. They found heavy metals exceeding 10 times background in the Hunter River located within the heavily industrialised and urbanised Newcastle region (Fig. 1), but 6 other rivers north of the area (including Richmond, Manning, Macleay, Clarence, Brunswick and Tweed Rivers), showed minor to no anthropogenic contamination. Pb isotopes showed that contamination away from industrial areas was localised to <1 km from point sources like sewage outlets and major highways.

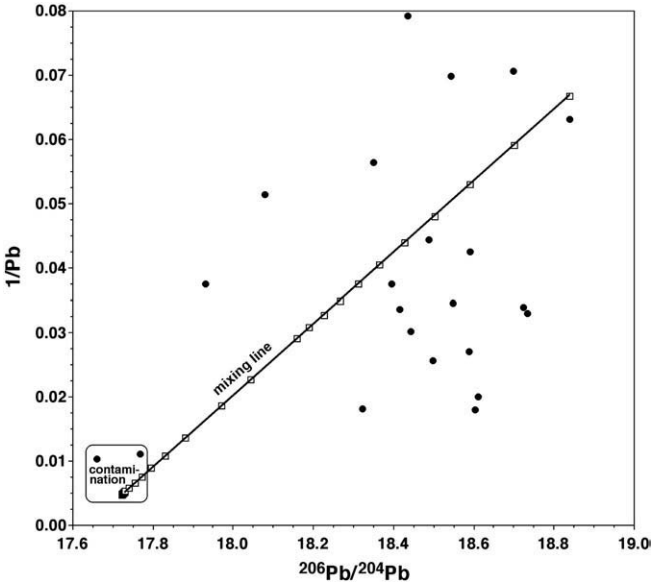

Fig. 4. Diagram showing 1/Pb concentration in ppm versus $^{206}Pb/^{204}Pb$ for the samples from the Murray Darling Basin (filled circles). Note 3 samples plot away from those considered to be of natural variability, and are likely to be contaminated by anthropogenic Pb with a Broken Hill isotopic signature. Included also is a mixing line calculated (open squares) by using end members that are extreme compositions observed in our data. Binary mixing arrays are linear on these types of plots regardless of the compositions of the endmembers; the poor correlation between Pb isotopic composition and Pb concentration in the MDB sediments further precludes anthropogenic contamination.

In another study, Ashley and Napier (2005) examined heavy metals downstream of the Port Macquarie urban area (Fig. 1) and found a clear signal of anthropogenic Pb, Cu, Zn and As in both element concentrations and Pb isotopes, but this contamination was restricted to the local catchment and did not extend downstream to the estuary. Finally, Martley et al. (2004), who assessed heavy metal concentrations around the very industrialised complex of Port Kembla (Fig. 1) where a copper smelter, steelworks, a fertiliser plant, a former base metal smelter and nearby coal mines are located, found that Pb drops rapidly in surface sediments, mostly below background levels, further than 10 km from the smelter. In addition, 'the extent of contamination emanating from the Port Kembla complex was limited to 1–13 km, but most likely <4 km' (Martley et al., 2004).

We analysed 2 regolith samples taken in the vicinity of Broken Hill to determine the possible level of contamination from the mine. The first sample [labelled 2–44: 31° 47.346′S, 141° 11.141′E] originates from the Mundi Mundi Plains, a location of much dust deflation, some 45 km NW of the town of Broken Hill [see Fig. 1]. The second sample [labelled 2–45: 32° 03.058′S, 141° 37.044′E] is located some 15 km SE of Broken Hill [see Fig. 1]. The Pb isotopic ratios of these samples show that sample 2-44 [$^{206}Pb/^{207}Pb = 1.1968$; $^{208}Pb/^{207}Pb = 2.4410$] is definitely not contaminated with Broken Hill mine signatures, whereas the other, 2-45 [$^{206}Pb/^{207}Pb = 1.0877$; $^{208}Pb/^{207}Pb = 2.3682$], has values approaching that of the Broken Hill ore body. This latter sample is located directly along the predominant wind direction, although, at times, winds to the NW of the mine and would pass over the Mundi Mundi Plains.

We therefore accept that anthropogenic contamination can be detected in a small subset of the MDB samples representing areas proximal to significant agricultural activities, but we reject the extreme conclusion of Kamber et al. (2010-this issue) that all of these samples are hopelessly contaminated.

2.2. The importance of grain size when analysing samples for Pb isotopes

We need to reiterate that we did not compare the EPICA Dome C data with that of other sites in Australia, except for the samples from the MDB, originally collected by Gingele and De Deckker (2005) and for which Pb isotopes are discussed by De Deckker et al. (2010), for the simple reason that the size fraction for all the samples analysed in ice cores is <2 μm. A recent study by Feng et al. (2010) clearly demonstrates that there is a grain size dependence on various Pb isotopes from four different loess sites and samples from 4 widely spaced locations in China. However, these authors could not define any specific trends in the Pb isotopic ratios for the different sizes [<2, 2–5, 5–10, 10–20, 20–32, 32–50 and >50 μm]. In addition, Feng et al. (2009) identified that Sr isotopes also strongly depend on grain size, and, this time, they argued that the $^{87}Sr/^{86}Sr$ increases with decreasing grain size. For Nd isotopes, on the contrary, those authors argue that Nd isotopic ratios appear to be independent of grain size.

As a corollary of the observations of Feng et al. (2010), we argue therefore that the approach in the De Deckker et al. (2010) paper when comparing EPICA Dome C Pb isotopic ratios from South American rock types, and not aeolian material, ought to be considered with caution. The same could be applied to the recent work of Vallelonga et al. (2010) who did not analyse the <2 μm size fraction for the Australian material.

2.3. The process of deflation and dust transport over large distances

Kamber et al. (2010-this issue) grant the possibility of dust transport from Australia to Antarctica, in agreement with the principal conclusion of De Deckker et al. (2010). It is important to be aware that extensive dust storms/events, while in the process of transgressing over any landscape, will continue to pick up dust from the regolith as it travels. This implies that at the location of eventual deposition, the sediment will have originated from several different sources and, therefore, it will be almost impossible to define the exact point of origin of a dust plume, and consequently an attempt at fingerprinting dust using a variety of geochemical proxies will involve using mixing lines as illustrated in our plots of the comparison of Australian samples with those that were eventually deposited within snow in Antarctica and eventually trapped in ice cores (see Figs. 7–8 in De Deckker et al. (2010)).

Recently, we collected dust samples during a major dust event that affected a large portion of eastern Australia in September 2009, with a dust plume originating south of the Lake Eyre region and that travelled as far as northern Queensland and New Zealand [where dust was deposited on glaciers], and even reached New Caledonia. Over a period of a few hours, the chemical, as well as Sr and Nd isotopic, composition of the dust collected in Canberra, and a few hours later at Eden, located southeast of Canberra [see Fig. 1], had significant differences, even though the samples were obtained from the same

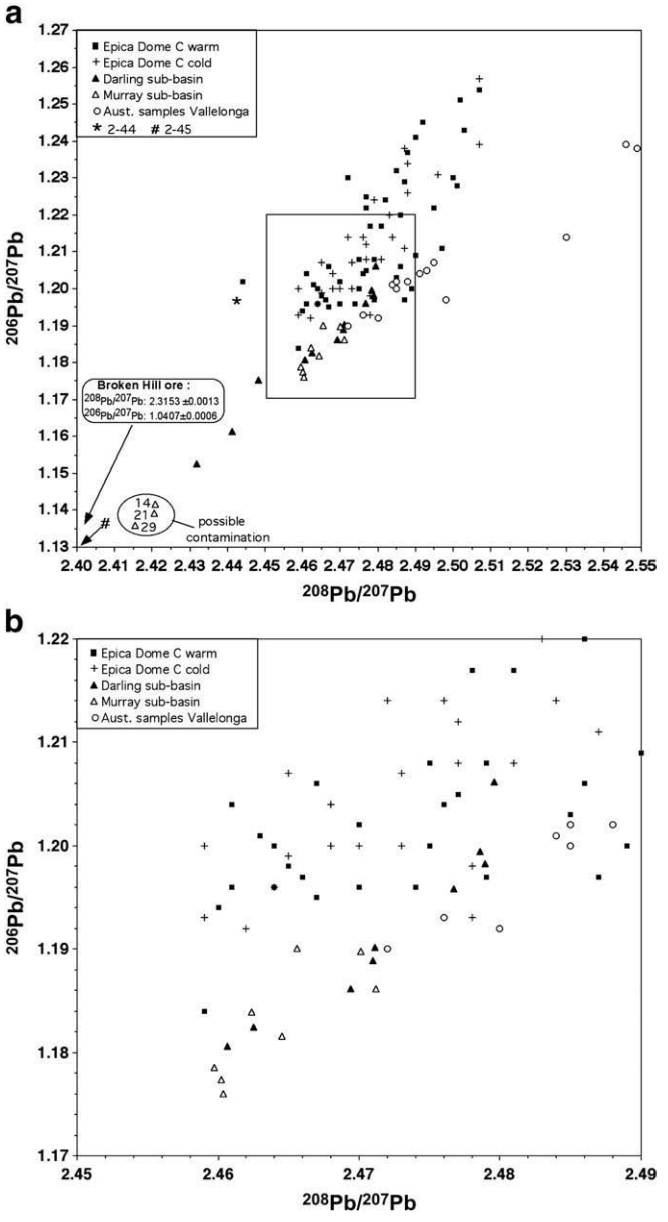

Fig. 5. (a) Diagram of $^{206}Pb/^{207}Pb$ versus $^{208}Pb/^{207}Pb$ for the Murray Darling Basin , for EPICA Dome C samples studied by Vallelonga et al. (2010) for Australian samples referred to in Vallelonga et al. (2010), and for samples 2-44 and 2-45, both located in the vicinity of the Broken Hill mine; (b) enlarged diagram (see box in Fig. 5a) to facilitate comparison of the EPICA Dome C samples with those from Australian Potential Source Areas.

dust storm. It is a well-known phenomenon that when a major atmospheric front transgresses the landscape and collects dust along its pathway, the airflow immediate of the front will collect additional aeolian material originating from a different source. For example, in the case of dust plumes travelling in a northeasterly direction, air will flow from a northerly to a northwesterly direction [for a clear schematic diagram, refer to Sturman and Tapper (1996: fig. 7.7)].

We, therefore, maintain our argument that the Darling sub-basin is a potential supplier of aeolian dust to the EPICA Dome C site. This conclusion is further confirmed by the additional analyses recently published by Vallelonga et al. (2010) and which were not available to us at the time of preparation and publication of the De Deckker et al. (2010) paper. Vallelonga et al. (2010) argued that of the samples collected by them in Australia [see values plotted in Fig. 5a and b; we only used 'extracted samples' as remarked by Vallelonga et al. (2010) who rightly stated that grain size is important to consider when measuring Pb isotopic ratios of PSA's], eight of the 74 samples analysed from the EPICA Dome C core overlap with Australian material, five corresponding to interglacials [Holocene 6.93 ka, plus 14.9 ka, 15.61 ka, 15.63 ka] and Eemian: 114.14 ka], and three to glacials [19.66 ka, 21.97 ka and 29.09 ka]. We show four additional MDB samples (Fig. 5a, b) that were collected from potential source areas for the Dome C core, while others are outside the narrow field of Pb isotopic values recorded by Vallelonga et al. (2010). It is not possible to state at this stage if those PSA samples relate to interglacial [warm] or glacial [cold] phases as the Darling sub-basin samples plot close to both warm and cold layers. We note also that several of Vallelonga et al.'s (2010) samples from Brachina Gorge located in Late Proteozoic formations plot in the top right corner of Fig. 5a. The same applies for one sample from the Lake Eyre region, and one from Lake Mungo that is located in the MDB. The values for these 2 latter samples cannot be explained at present as no precise information on sample location was provided. Nevertheless, new Sr and Nd analyses of surficial samples from the Lake Eyre Basin and from adjacent regions (De Deckker and Norman, unpublished data) indicate that the Lake Eyre Basin is also a plausible supplier of dust to Antarctica for various ice core sites.

3. Conclusion

We conclude that useful information on the Pb isotopic compositions of potential dust source areas can be obtained from surficial sediments within the MDB fluvial system, and that some of these sediments, especially within the Darling catchment, represent potential source areas for Antarctic dust.

De Deckker et al. (2010) argued that the Darling basin of eastern Australia was a plausible source of Antarctic dust on both chemical and physical grounds, including direct visible observations of dust transport during a recent storm. Kamber et al. (2010-this issue) distorted this argument by incorrectly suggesting that we proposed an exclusively Australian source for Antarctic dust. As shown by Vallelonga et al. (2010) and reiterated by Kamber et al. (2010-this issue), several potential dust sources areas in both Australia and southern South America have sufficiently similar Sr, Nd and Pb isotopic compositions that it is difficult to distinguish them by these criteria. We agree with Kamber et al. (2010-this issue) that additional studies utilising mineralogy, trace elements, and additional isotopic tracers in concert with physical models and observations of actual dust transport events will help elucidate the source and significance of paleoclimatic dust records.

Erratum to De Deckker et al. (2010)

In De Deckker et al. (2010) two figures are incorrectly positioned. The images in Figs. 5 and 6 should be switched, but respective captions are to remain in the same position.

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