

Extrusive Phase of Carbonatite–Alkalic Activity in Amba Dongar Complex, Chhota Udaipur, Gujarat

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Abstract: It is noteworthy that Amba Dongar carbonatite complex has both intrusive and extrusive phase carbonatites. The stratified tuff with components of both carbonatite and nephelinite have been recently traced in western part of Amba Dongar complex. In this preliminary report we present trace and rare earth elements data and C and O isotopes of these tuffs. The C and O isotopes of the least altered tuff falls within the mantle box while the remaining samples plot in the narrow field of 16-20% in oxygen. These values are explained using simple model of water-rock interaction.

Keywords: Carbonatites, Extrusive phase, Amba Dongar, Gujarat.

Introduction and Field Geology

Although there has been considerable interest in extrusive carbonatite, and several have been described, there are very few examples of intrusive carbonatite complexes that are accompanied by an extrusive phase. The well known Amba Dongar carbonatite-alkalic rock complex is such a case, and the extrusive portion has not previously been documented. It is a sub-volcanic diatreme with a ring dike of sövite collaring the inner rim of carbonatite breccia. The ankeritic carbonatite, younger in the carbonatite sequence, forms small and large plugs intrusive into sövite. Nephelinite plugs form a discontinuous ring around the central ring complex at lower altitude, while phonolites occur as small and large dikes intrusive into basalt, sandstone and nephelinite. The central depression of the ring complex is occupied by basalt that post-dates the carbonatite-nephelinite activity (Viladkar, 1996). The extrusive phase of carbonatite-nephelinite volcanism at Amba Dongar was unknown until it was first reported by Viladkar et al. (2001).

The outcrops of stratified tuff with components of both carbonatite and nephelinite have been recently traced in the vicinity of Mongra village (Fig.1) situated west of the main carbonatite-alkalic ring complex of Amba Dongar. The outcrops extend up to 2 km in a slightly arcuate manner, being generally aligned in a northwesterly direction, and having a focal point close to the main carbonatite-alkalic intrusive ring of Amba Dongar.

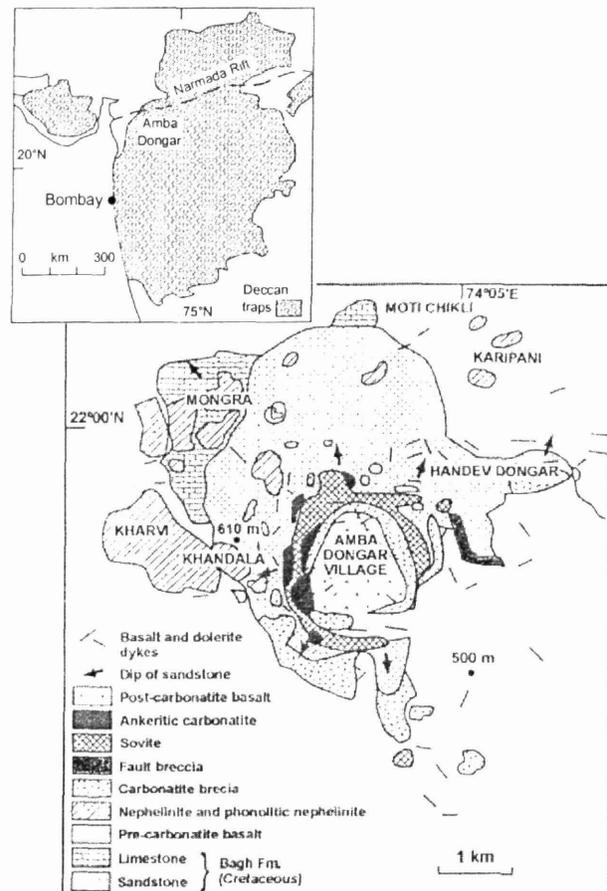


Fig.1. Geological map of Amba Dongar (Mongra is in western part of map).

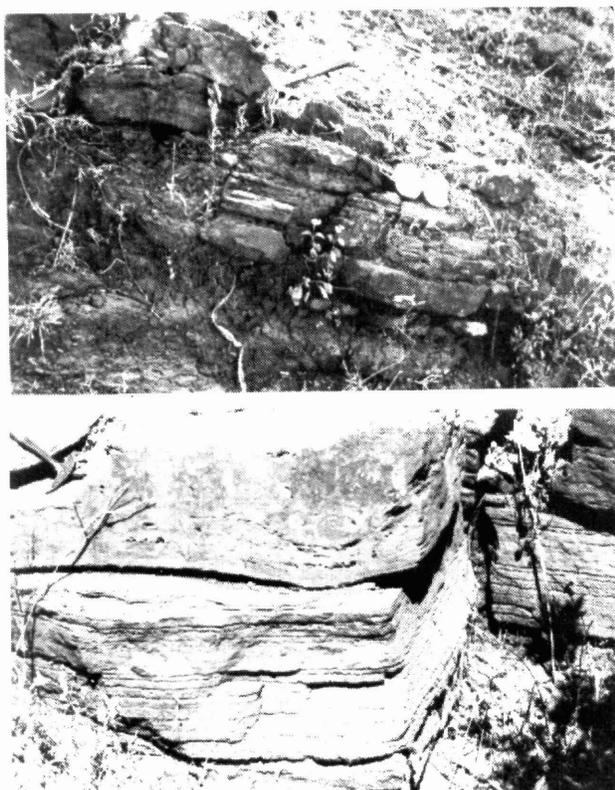


Fig.2. A and B. Field photograph of bedded tuff in the Western part of Amba Dongar at Mongra.

The tuff formation (Figs.2A and B) has a gentle to moderate southwesterly dip with individual beds from a few mm to several centimeters thick. The thicker unit is characterized by graded bedding.

The aerial extent and stratified nature of this tuffaceous formation indicate deposition in an aqueous body of considerable size. The development of cross bedding suggests periodic fluctuation of water depth.

The textural and depositional features of these tuff beds suggest that they were deposited closer to the vent through which the carbonatite-alkalic rock tuffs were ejected and deposited in thermal pools associated with carbonatite-nephelinite volcanism at Amba Dongar.

The rock is mainly an extremely fine grained lithic tuff interspersed with crystal fragments of carbonates, nepheline, altered olivine, pyroxene and melanite garnet; thus, its composition is carbonatite-nephelinite. In each of the strata the lower portion contains coarser crystal fragments, in contrast to the very fine grained to glassy upper part. The notable feature of this stratified formation is the occurrence of brownish, iron-rich cherty silica layers, which are intercalated with the tuffaceous strata. These chert layers are mostly a few centimeters in thickness; however, some of them are much thicker and are very prominent.

Geochemistry and Discussion

For comparison of trace elements, separate spider diagrams of tuffs rich in nephelinite fraction and carbonatite fractions are shown in Figs.3A and B respectively. In Fig. 3A samples of nephelinitic tuff and a sample of nephelinite from one of the plugs show practically similar patterns, however, their trace elements concentrations differ. Accordingly, tuff shows high concentration of Rb, Ba, Th and U over nephelinite while concentrations of Nb, LREE and Sr are more in nephelinite. High Rb and Ba in tuffs could be attributed to abundant xenocrysts of K-feldspar in these rocks. In Fig.3B, compared to first phase

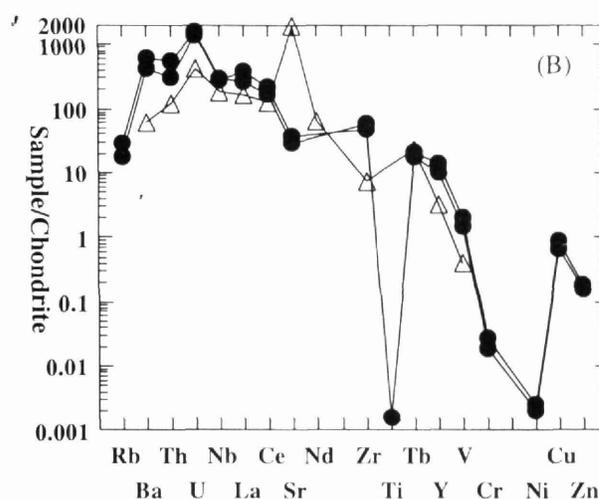
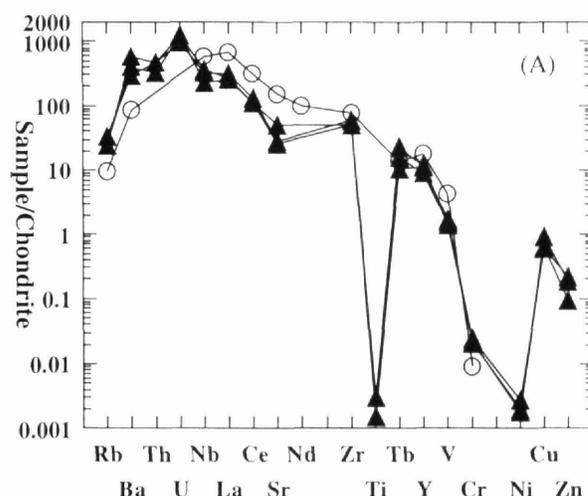


Fig.3. (A) Spider diagram of nephelinitic tuff and nephelinite of Mongra (Filled triangles – nephelinitic tuff, Open circle- Nephelinite from Amba Dongar). (B) Spider diagram of carbonatite-rich fraction of tuff and early calcitic carbonatites (Filled circles-carbonatitic tuff, Open triangle-carbonatite of Amba Dongar).

carbonatite of the Amba Dongar ring dyke, the carbonatite-rich fraction of tuff shows higher concentrations of all trace elements except Sr.

The chondrite normalized REE patterns of tuffs (nephelinitic and carbonatitic fractions) are compared with nephelinite and calcitic carbonatite of Amba Dongar and are shown in Figs 4 A and B respectively. The REE distribution patterns of tuff samples rich in nephelinitic fraction (ruled area) and that of nephelinite (Fig 4A) are very similar though nephelinite has a higher concentrations of LREE than tuffs, while HREE concentrations and distribution patterns are almost identical. The Chondrite normalized REE distribution patterns of two samples rich in carbonatite components (horizontal lined area) are

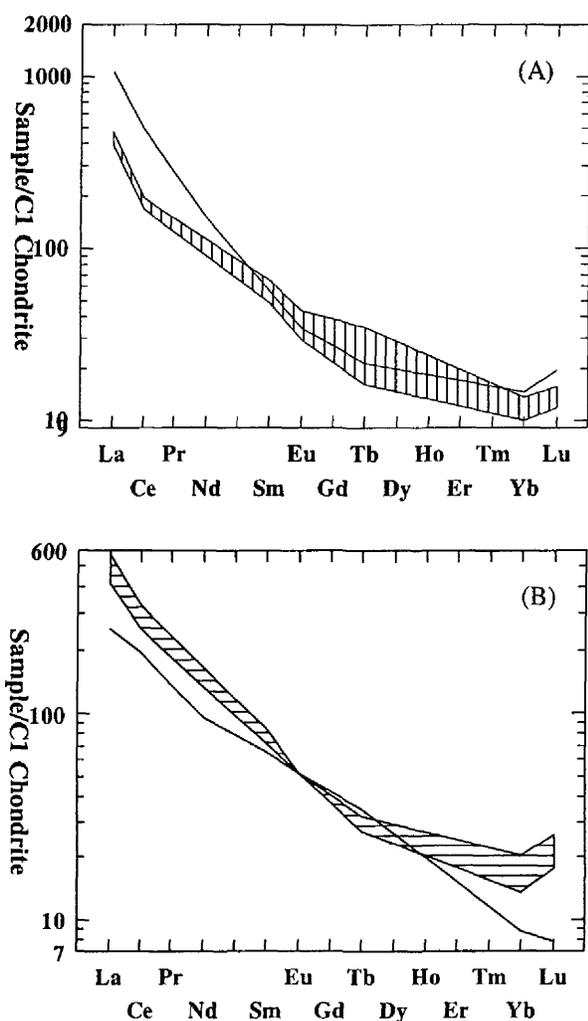


Fig.4. (A) Chondrite normalized REE patterns of tuffs rich in nephelinitic fraction (ruled area- range of REE in tuff samples) compared with nephelinite of Amba Dongar (B) Chondrite normalized pattern of tuff rich in carbonatitic fraction (horizontal lined area-range of REE in tuff samples) compared with early sovite of Amba Dongar

Table 1. Trace and rare earth elements in tuff samples of Mongra (all data in ppm)

Sample	CT	CT	NT	NT	NT	ADNE	ADCAR
Ba	2100	1452	1009	1944	1335	290	211
Rb	98	61	113	85	81	32	
Sr	334	430	595	336	3309	1733	22407
Nb	107	104	131	119	83	214	70
Zr	327	263	278	324	280	41	40
Y	30	22	20	26	25		7
Th	23	13	20	20	14		5
U	19	17	15	20	14		5
Cr	106	74	87	96	83	35	
Ni	41	33	25	45	32		
Co	29	22	25	26	18		
V	168	125	129	147	116	368	33
Cu	146	113	156	101	106		
Pb	21	73	97	28	15		
Zn	84	73	84	98	43		
La	98	136	97	110	93	250	60
Ce	154	200	104	120	102	300	120
Nd						700	45
Sm	11	13	7.5	10	8		10
Eu	3	3	2	2.5	17	2	3
Tb	1.2	1	0.9	1.3	0.6	0.8	1.3
Yb	2.3	3.5	1.7	2.3	1.8	2.5	1.5
Lu	0.45	0.66	0.35	0.4	0.3	0.5	0.2

CT - Tuff with more carbonatite component NT - tuff with more nephelinite component, ADNE - Nephelinite of Mongra ADCAR - Early phase of calcitic carbonatite of Amba Dongar

The trace elements were determined on XRF at Mineralogical Petrographisches Institute, Hamburg University, Germany REE s were analysed at the Bhabha Atomic Research Centre, Trombay, Mumbai

compared with early calcitic carbonatite from Amba Dongar in Fig.4B. The carbonatitic tuff show higher concentrations LREE and HREE than calcitic carbonatites of Amba Dongar. The tuff also shows prominent negative Yb anomaly.

Stable oxygen ($\delta^{18}\text{O}$ relative to the SMOW standard) and carbon ($\delta^{13}\text{C}$ relative to the PDB standard) ratios of seven representative samples were measured using a GEO 20-20 mass spectrometer with a precision better than $\pm 0.1\%$ (Fig 5). One of the samples falls within the mantle

Table 2. C and O isotopes in tuff samples of Mongra

Sample	^{13}C	^{18}O
CT	5.2	9
CT	7.8	19.2
NT	8.8	16.2
NT	9	16.2
NT	8.9	18.1
NT	8.9	19

CT - Tuff with more carbonatite component, NT - tuff with more nephelinite component,

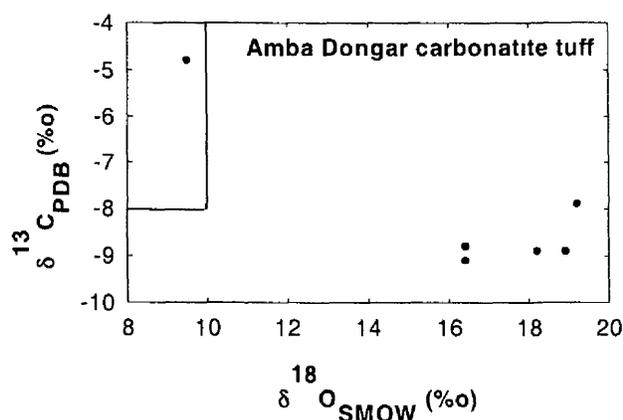


Fig.5. ^{18}O - ^{13}C plot of the tuffs

box (-4 to -8‰ in carbon and 8 to 10‰ in oxygen isotopes respectively), possibly indicating the original or least altered isotopic composition of the tuff carbonate. The remaining samples plot in a narrow field of 16 to 20‰ in oxygen with

carbon isotopes close to -9‰. Using a simple model of water-rock interaction, these values can be explained by interaction with a magmatic fluid at 200°C, with the fluid composition given by -8‰ and +10‰ respectively for carbon and oxygen isotopes, with the molar ratio of carbon dioxide to water of 0.1 and a fluid/rock carbon ratio of 5. Alternatively, one can explain the low carbon isotope ratios by interaction with carbon dioxide derived from vegetation, which could have a ratio as low as -27‰. The dissolved carbon dioxide in open water bodies could fluctuate with evaporation and precipitation cycles and at present it is difficult to distinguish between the two alternatives, with the limited available data. The stable isotope results are consistent with the geological field evidence discussed above.

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