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Magnetic Character of Alkali Rocks from Northwest India

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ABSTRACT

Magnetic property investigation of some alkali rocks from western and northwestern India has been undertaken with a view to understand their magnetic behaviour. The rock types investigated include ultramafics, carbonatites, gabbros, lamprophyres, syenites, basalts, dolerites and alkali dykes collected from 14 sites in the states of Rajasthan and Gujarat. Natural Remanent Magnetic intensity (Jn), Susceptibility (K), Koenigsberger Ratio (Qn), laboratory demagnetizations using AF and thermal methods, Saturation Remanent Hysteresis, Susceptibility variation with Temperature, Lowrie-Fuller Test and petrographic observation are some of the studies carried on these rocks. Most of the magnetic properties observed on these rocks show a wide variation, over 2-3 orders in magnitude, justifying their varying lithologies and magnetic mineral content. These alkali rocks reveal a spectrum of grain size with varying remanent and coercive forces noticed on them. The important magnetic mineral is (titano)magnetite occurring in CD and CD+MD domain states. These alkali rocks demonstrate extreme stability of the magnetic signature with very high median destructive field (mdf) values in excess of 10 to >100 mT without superposition of any high blocking temperature secondary over-prints.

INTRODUCTION

The Deccan flood basalts in the central and western parts of India are exposed over an area of nearly 500,000 sq. km. These are tholeiitic in the east and southeast but varies from tholeiitic to alkaline in the west and northwest (Vandamme, Courtillot & Besse 1991). Alkaline rocks are of special interest to geologists because of their exciting and perplexing mineralogy, coupled with extreme variability, variety of petrographic and chemical types, inclusion of mantle derived rocks and minerals associated with economic mineral deposits and their utility in providing clues in understanding the evolution of the Earth (Leelanandam 1989). The alkaline (and peralkaline) magmatism associated with or subsequent to the Deccan basalt volcanism is spectacular for its richness and variety. It is mainly confined to certain parts of Rajasthan and Gujarat (Subba Rao 1972; Bose 1980; Leelanandam 1989; Srivastava 1989). Geochronologic and geochemical properties of the alkali igneous complexes of the northwest Deccan Traps from Rajasthan and Gujarat have been used in proposing the model of a rising plume for the continental flood volcanism for these rocks (Basu et al. 1993). Palaeomagnetic results of these alkali rocks were reported by Poornachandra Rao, Mallikharjuna Rao & Jaya Prasanna Lakshmi (2000). A number of alkali carbonatite bodies associated with the Deccan traps are exposed along the Narmada valley and along the fault zone parallel to the west coast of India through the Cambay basin, which is an ideal tectonic setting for emplacement of alkaline volcanic complexes. Magnetic property investigation is essentially useful on such rock types which range from ultramafic to felsic and found in plutonic, hypabyssal and volcanic association that throw light on their evolutionary history. Identification of the magnetic carrier and inference of its domain state are very important in any palaeomagnetic study (Poornachandra Rao, Mallikharjuna Rao & Jaya Prasanna Lakshmi 2000) in order to rely on the remanent magnetic signature isolated from it. For this purpose a number of magnetic properties, which are different from the routine palaeomagnetic study, are essential. The magnetic properties investigated include remanent magnetic intensity, susceptibility, Koenigsberger Ratio, laboratory AF and thermal demagnetizations, Lowrie-Fuller test, saturation remanent hysteresis, K-T studies and petrographic observation of some of these alkali rocks from Rajasthan and Gujarat and the results of these studies are presented in this paper.

GEOLOGY

The Deccan traps were poured out during late Cretaceous - early Tertiary period over a very large area in the central and western parts of India in very quick succession. These are mostly tholeiitic and subordinate alkaline varieties in northwestern part in Rajasthan and Gujarat. It is generally believed that alkaline magma generation is restricted to thicker lithospheric regions that have lower thermal gradients than vigorously spreading or converging plate regimes. But in recent years there is an increasing awareness that alkaline magmatism is not restricted to any single scenario but may occur in virtually all tectonic and petrologic settings (Leelanandam 1989). Several alkali igneous complexes occur in extensional zones around a region of high heat flow and positive gravity anomaly within the continental flood basalt province of northwestern India (Subba Rao 1972; Bose 1980; Basu et al. 1993). A number of alkaline-carbonatite bodies associated with Deccan tholeiites outcrop along the Narmada valley, a rift extending eastward from the Cambay basin and along another prominent N-S fault zone parallel to the west coast of India, extending through the Cambay basin possibly as much as 600 km to the north (Fig. 1). This fault zone also includes alkali rock complexes of the Bombay area. Thus the western and northwestern India with the above geological settings provide an unique tectonic framework for emplacement of alkaline volcanic complexes.

A number of rock types such as ultramafics, carbonatites, gabbros, lamprophyres, syenites, basalts, dolerites, alkali dykes etc. occurring around Mundwara, Barmer, Sarnu-Dandali, Phenaimata and Ambadongar were collected for the present study. The syenites are medium to coarse grained rocks with considerable mineralogical variation and well preserved low grade metamorphic effects. Porphyrytic types are present with clinopyroxene or sanidine (K-feldspar) as phenocrysts. Magnetite is distributed as specks and needles throughout the rock.

Gabbros are coarse grained dark coloured rocks showing mafic layering represented by clinopyroxene, olivine and magnetite. The clinopyroxenes are titaniferous and contain fine inclusions of opaque needles arranged zonally or parallel to cleavage. Magnetite (up to 6 % by volume) is associated with clinopyroxene, olivine, biotite and at times seen as inclusions in these minerals. Basaltic rocks are fresh, massive (rarely porphyrytic) and fine grained with typical flow textures. In the porphyrytic types the phenocryst phase mostly aggregates of plagioclases and rarely clinopyroxenes. The clinopyroxenes are titaniferous and at times show undulatory extinction and rarely feeble composite zoning. They show least alteration effects. Magnetite is seen throughout the matrix as fine grained specks and needles and as subhedral/euhedral individual grains in the rock. Carbonatites are light pink in colour and iron rich varieties show brown color. Though calcite is the primary mineral in the carbonatites, it is not typical calcite that occurs in these carbonatite rocks. Primary and secondary ore minerals represented by magnetite and haematite are common. The other typical accessory minerals like apatite, zircon etc., and other mafic minerals are absent in these carbonatites and they are contaminated by the surroundings. Lamprophyres are panidiomorphic textured rocks with biotite, potash feldspar (orthoclase) and clinopyroxene as essential constituent minerals. These lamprophyres are relatively biotite poor and show porphyrytic textures. The phenocryst phases show euhedral growth mostly represented by clinopyroxene, potash feldspar,

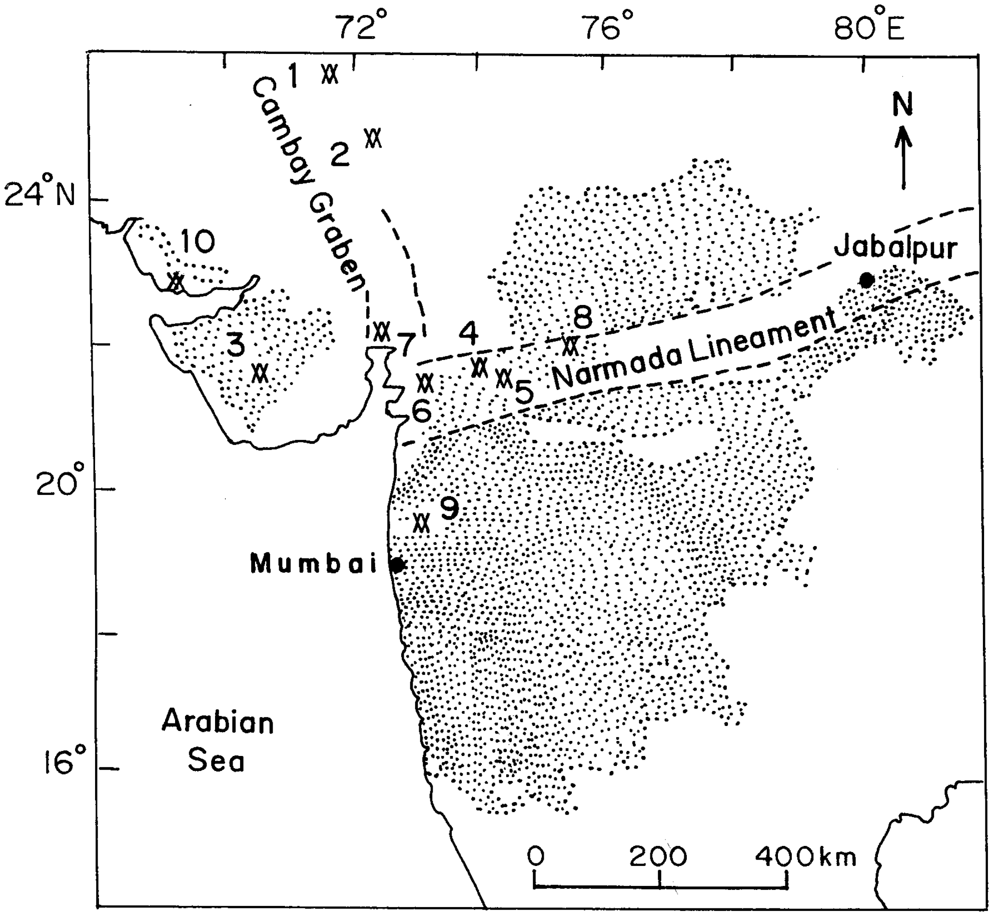

Figure 1. Sketch map of part of the Indian peninsula showing the location of alkali igneous complexes from western and northwestern India associated with the Deccan Traps. (1. Sarnu-Dandali, 2. Mundwara, 3. Mount Girnar, 4. Phenaimata, 5. Ambadongar, 6. Netrang, 7. Kadi, 8. Barwaha, 9. Jawahar, Bombay, 10. Kutchch).

biotite and opaques (magnetite). They show minor alteration effects.

Basu et al. (1993) obtained Ar/Ar ages from alkali olivine gabbro from Mundwara complex and alkali pyroxenite from Sarnu of the Sarnu-Dandali complex which are 68.53 ± 0.16 and 68.57± 0.8 Ma respectively. They also dated an olivine gabbro from Phenaimata complex by Ar/Ar method and obtained an age of 64.96± 0.11 Ma.

Oriented block samples form these alkaline complexes from Mundwara, Sarnu-Dandali, Tavidar, Barmer, Phenaimata and Ambadongar were collected for detailed palaeomagnetic and magnetic property investigations from 14 sites. Cylindrical specimens were prepared from these samples by drilling 25.4 mm diameter and 22 mm height specimens and a total of 433 cylindrical specimens were obtained from 76 samples from 14 sites.

LABORATORY INVESTIGATIONS

Natural Remanent Magnetism (NRM) of all the specimens was measured on a spinner magnetometer (DSM-2, Schonstedt, USA). A.F. demagnetization was carried out on an AF demagnetizer similar to that described by Creer (1959) and thermal demagnetization on the Schonstedt thermal demagnetizer (TSD-1). Susceptibility was measured on a Low Field Hysteresis and Susceptibility Apparatus by Likhite & Radhakrishnamurty (1965). Remanent hysteresis properties were studied using an electromagnet by magnetizing the specimens in DC fields up to 1 Tesla following the method of Carmichael (1961). Susceptibility variation with temperature was studied by cooling the specimens to liquid nitrogen temperature and observing their susceptibility as the specimens warm to attain ambient temperature (Radhakrishnamurty & Deutsch 1974). Lowrie & Fuller (1971) Test was carried out by saturating the specimens using an electromagnet and progressive AF demagnetization in identical steps as that of NRM and comparing their demagnetization spectra.

Natural Remanent Magnetism

Natural Remanent Magnetic (NRM) direction and intensity of all the specimens were measured. NRM vectors of specimens from all the sites show good grouping. NRM intensity (Jn) and susceptibility (K) of these rocks show wide variation over two-three orders justifying the different rock types involved. Jn varies between 0.05 and 19.55 A/m and K between 0.44 and 65.94 x 10^{-3} SI units. The Koenigsberger Ratio (Qn) ie., the ratio of remanent to induced intensities has been evaluated using a value of 0.05 mT for the Earth's magnetic field. It varies between 1 and 38. The range and mean values for all the rock types investigated are listed in Table 1. NRM vectors indicate grouping with normal and reversed vectors with upward and downward inclination. Stability of the remanent vector of these rocks is tested using laboratory AF and thermal demagnetization methods.

Laboratory Demagnetizations

From each site 2-3 specimens representing different groups of remanent magnetization directions were selected and subjected to AF demagnetization in increasing peak fields on a pilot basis in steps of 5 to 10 mT up to a peak field of 100 mT. The specimens exhibit very good behavior to A.F demagnetization indicating stable nature of the remanent magnetization vector. Some specimens indicate removal of weak viscous components before reaching the stable direction during successive steps of demagnetization. However, some specimens are quite stable without acquisition of any viscous components as revealed by the possession of similar vector in successive demagnetization treatment (Fig.2a). The median destructive field (mdf) values of these specimens range from 10 mT to as high as >100 mT. The remanent intensity decay pattern of these rocks is shown in Fig 2b. which reveals very hard nature of the remanent magnetization vector and in no case the remanent intensity would be completely demagnetized. Even at 100 mT peak field variable amounts of remanent intensity remains.

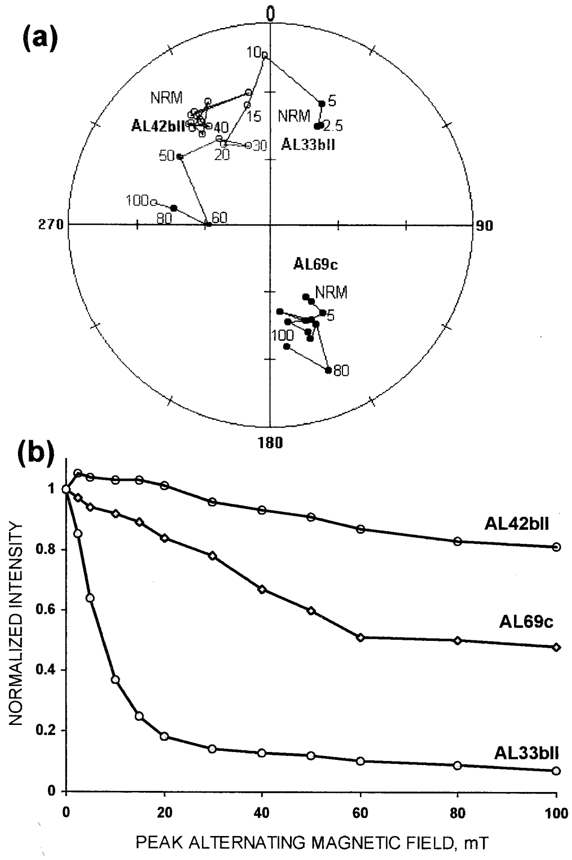

Figure 2. (a) Stereographic plot showing vector migration and (b) normalised intensity decay plot of typical pilot specimens subjected to AF demagnetization from alkali igneous complexes. Very hard nature of the remanent vector in these rocks can be seen from vector response and high mdf values.

Similarly for thermal demagnetization also 2-3 specimens from each site representing these rocks from various groups of remanent magnetization directions were selected and subjected to thermal demagnetization in increasing temperatures up to 600 ^{0}C in steps of 50 to 100 ^{0}C on a pilot basis. Remanent magnetization vector behaviour of these specimens is identical to that of AF demagnetization treatment. In thermal demagnetization also some specimens reveal acquisition of weak viscous components that are removed in temperatures of 100 to 200 ^{0}C and thereafter retaining the stable primary vector acquired at the time of formation of these rocks. There are also some specimens, which do not show acquisition of any viscous or secondary components as seen by the identical remanent magnetization vector throughout the thermal treatment (Fig.3a). Intensity decay behaviour of these specimens to thermal demagnetization is shown in Fig.3b. Majority of the specimens exhibit high blocking temperatures between 550 and 580 ^{0}C and few samples show blocking temperatures at 200 and 580 ^{0}C, indicating presence of magnetite and titanomagnetite as the carrier of remanent magnetization in these rocks.

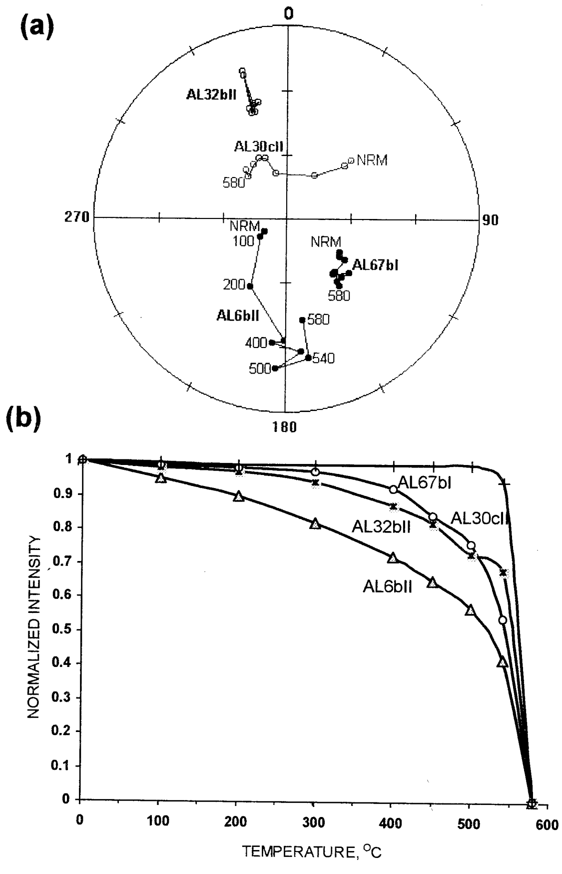

Figure 3. (a) Stereographic plot showing vector migration and (b) normalised intensity decay plot of typical pilot specimens subjected to thermal demagnetization from alkali igneous complexes. The blocking temperatures, as can be seen from these curves, reveal presence of (titano)magnetite as the carrier of remanent direction in these rocks.

Saturation Remanent Hysteresis

In order to understand the complete magnetic nature of these rocks as many as twenty four specimens were selected from all the fourteen sites and subjected to saturation remanent hysteresis studies. The 25.4 mm diameter and 22 mm long specimens were placed in between the pole pieces of an electromagnet and DC magnetic fields were applied to induce IRM in the specimens in steps of 10 to 100 mT up to a maximum value of 1 Tesla. Induced magnetization was measured after each step of magnetization using an astatic magnetometer. When the specimen acquires saturation the orientation of the specimen between the pole pieces was reversed and again magnetized till saturation is attained in the opposite direction (reversed field). The same procedure has been once again repeated to get the complete hysteresis properties following the method of Carmichael (1961). Observed coercive forces (Hc) of the rocks indicated a broad range of coercive forces between 8.8 and 215.4 mT requiring saturating fields (Hs) between 100 and 750 mT. The measured saturation intensities (Js) of the rocks vary from 8.4 to 74.5 A/m. Typical examples of saturation remanent hysteresis in case of few rock types are shown in Fig.4 that depicts their varying hysteresis properties. Their hysteresis parameters are listed in Table 2.

Susceptibility Variation with Temperature

Radhakrishnamurty & Deutsch (1974) demonstrated some simple experiments on basaltic rocks to quickly infer the domain states of magnetic carriers in them. The susceptibility variation with temperature is one among them, which distinguishes between different domain states through their characteristic susceptibility properties. In the present study several specimens from each site from all rock types were subjected to these studies by observing their K – T behavior. The specimens were measured for their susceptibility at room temperature and then immersed in liquid nitrogen which cools them to –196^{o} C. Then the specimens were immediately transferred in to the pick up coil of the susceptibility apparatus and the variation in the susceptibility has been continuously monitored as the specimen warms up to the room temperature. Relative Susceptibility (RS) value and susceptibility peak values were computed by dividing the susceptibilities at –196^{o} C and –156^{o} C with that value at room temperature and are listed in Table 2. Typical susceptibility variation with temperature for few specimens in the low temperature region is shown in Fig 5. On the basis of K – T variation, two groups of magnetic domain character seems to exist in these rocks. The first group of rocks with RS values been 0.56 and 0.98 with susceptibility peaks between 1.07 and 1.47 and the second group of rocks with RS values between 1.04 and 3.0 with out any susceptibility peak.

Lowrie – Fuller Test

Lowrie & Fuller (1971) suggested yet another method to quickly infer the domain nature of magnetic minerals occurring in igneous rocks. This method involves comparing the AF demagnetization

Table 1. Magnetic Properties of Some Alkali Rocks, Northwest India

Site No	N(n)	Rock type	Jn x A/m Range		Mean	K x 10^{-3} SI Range		Mean	Qn-Ratio Range		Mean
1	3(15)	Syenite	1.05	7.50	2.60	0.17	4.37	1.21	0.08	1.01	0.37
	2(12)		15.00	68.17	43.42	—	—	—	—	—	—
2	5(30)	Syenite	0.08	4.70	1.24	2.46	6.70	3.81	0.50	10.68	4.43
	2(12)		—	—	—	—	—	—	9.05	25.64	15.42
3	3(16)	Ultramafic	0.30	2.54	0.87	0.27	0.96	0.59	13.70	51.41	27.23
	2(9)		—	—	—	—	—	—	37.46	93.90	56.33
4	6(37)	Alkali dyke	0.02	0.13	0.05	0.27	0.82	0.44	1.51	12.07	3.68
5	2(12)	Alkali dyke	0.43	6.48	2.82	5.45	11.62	9.67	1.01	4.65	2.81
	4(20)		—	—	—	25.42	66.70	38.04	—	—	—
6	5(31)	Gabbro	1.09	9.94	5.01	26.24	110.16	65.94	0.25	4.15	2.13
	2(9)		34.79	85.04	60.16	—	—	—	15.21	33.94	24.85
7	4(23)	Gabbro	1.19	4.25	2.41	29.52	93.07	52.40	0.63	1.89	1.21
8	2(11)	Basalt	1.07	10.77	3.90	12.16	26.24	21.20	0.88	12.44	2.43
	3(19)		—	—	—	27.47	141.86	85.54	—	—	—
9	4(21)	Dolerite	0.61	21.33	9.69	19.14	41.27	32.17	0.63	13.83	6.91
	1(5)		43.34	81.88	64.65	—	—	—	41.98	68.76	59.97
10	5(27)	Syenite	0.06	1.10	0.37	2.87	10.66	5.70	0.50	4.02	1.52
11	3(20)	Gabbro	0.72	6.28	4.05	2.60	17.22	9.05	3.77	16.09	5.44
	3(16)		—	—	—	19.68	96.34	53.70	—	—	—
2	5(28)	Carbonatite	0.03	1.43	0.39	0.27	4.24	1.31	1.13	27.65	8.35
13	5(26)	Carbonatite	0.02	0.13	0.05	0.27	0.82	0.45	1.89	4.78	2.57
14	6(23)	Lamprophyre	0.02	4.28	1.89	32.26	72.31	59.41	0.01	1.63	0.81

N = No. of Samples
n = No. of Specimens
Jn = Natural Remanent Magnetic Intensity
K = Magnetic Susceptibility
Qn-Ratio = Koenigsberger Ratio

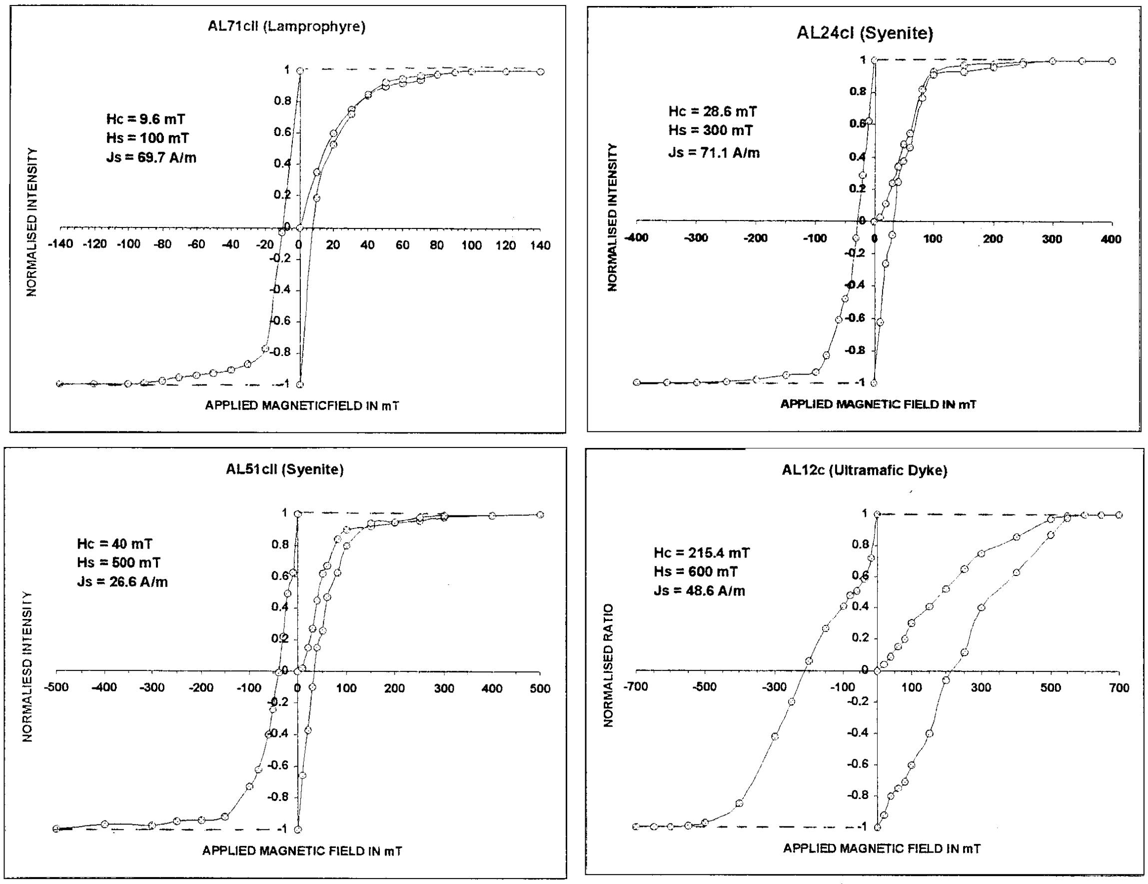

Figure 4. Remanent hysteresis curves of typical specimens from alkali igneous complexes. Intensities are normalized. Hysteresis parameters are also indicated (See Table 2 also).

spectra of NRM and laboratory induced S_{IRM} and depending on the hard and soft nature of NRM to S_{IRM} it is possible to infer that the magnetic carrier in them is in single domain (SD) or in multi domain (MD) state. This test also has been affected on the alkaline rocks with varying lithology, grain size and magnetic minerals in them. Selected specimens from all the sites were given laboratory S_{IRM} in a field of 1 Tesla and demagnetized in AF fields similar to that of NRM. The NRM and S_{IRM} AF demagnetization spectra are compared in Fig. 6. It can be seen that the S_{IRM} demagnetization spectra is soft in case of majority of rock types. However, the demagnetization spectra of NRM and S_{IRM} for some rocks also exhibit criss-cross behaviour.

DISCUSSION

We have undertaken a number of investigations described in the section "Laboratory Investigations" on the alkali rocks with different lithologies which throw light on various magnetic properties. The results of these investigations are also reported in the respective sections along with figures and listed in Tables 1 and 2. The basic magnetic properties of these rocks such as remanent intensity and susceptibility reveal a wide spectrum of values varying over two-three orders in magnitude. This is justified in view of the differing lithologies involved in the studies. The Qn- Ratio (Koenigsberger Ratio) evaluated from the measured intensity and susceptibility values on these rocks is well with in those reported for volcanic rocks. Generally, igneous rocks with Qn-Ratio between 1 and 100 are supposed to contain very stable remanence in them (Nagata 1961; Stacey 1963; Radhakrishnamurty 1970)

Through laboratory demagnetization using alternating magnetic and thermal fields it is possible to understand the magnetic and thermal history of rocks. This reflects their magnetic properties such as nature, grain size, oxidation state, magnetic mineral present etc., in these rocks. The AF demagnetization of the alkali rocks reveal very stable nature of the remanent vector with very hard behavior indicating fine grained nature of the magnetic carrier mineral which is insensitive to acquisition of magnetic components after its initial formation. This is evident from the fact that the median destructive field (mdf) values of these rocks range from 10 mT to > 100 mT. In case of no specimen the remanent intensity is completely demagnetized and various percentage of remanent intensity still exists even at the peak field

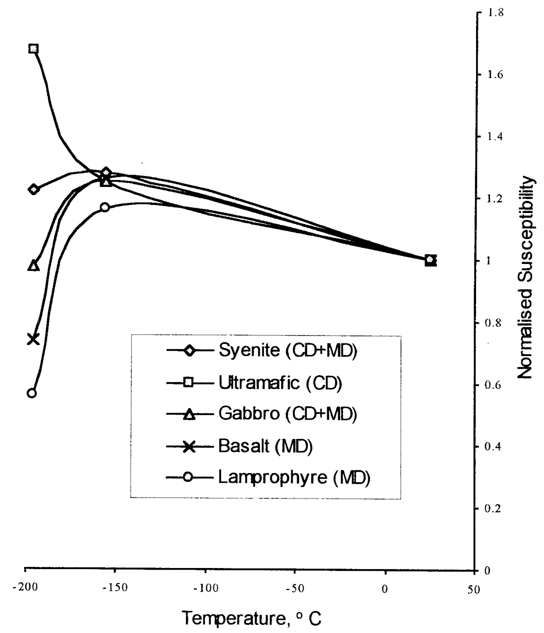

Figure 5. Susceptibility versus temperature variation (K-T) behaviour of some typical alkali rocks in the low temperature region up to liquid nitrogen temperature. Normalised susceptibility values are plotted.

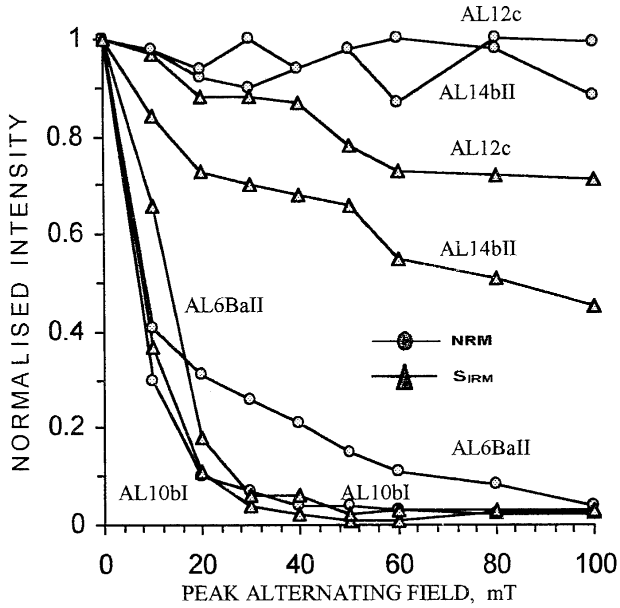

Figure 6. The AF demagnetization curves of NRM and S_{IRM} of the specimens.(Lowrie-Fuller test) from some alkali igneous complex rocks investigated.

of 100 mT. The thermal history of the rocks is also quite clear from the absence of high temperature secondary magnetizations noticed during their heating. The two blocking temperatures of 200 and 580 ^{0} C indicate presence of two magnetic carriers such as titanomagnetite and magnetite in these rocks in variable amounts.

Remanent magnetic signature in rock is dependent on its grain size that is characteristic of its volume in blocking the magnetization as the magma cools from high temperatures (Tarling 1973). The grain volume and coercive force are inversely related and therefore, it is possible to understand the ability of the rock to acquire and retain it through geological periods by a study of its coercive force (Hc). The Saturation Remanent Hysteresis study undertaken on the alkali rocks reveal coercive forces ranging from 8.8 to 215.4 mT and saturation intensities between 8.4 and 79.6 A/m indicating a spectrum of grain size of the magnetic carrier in these rocks. The observed hysteresis parameters are listed in Table 2. In igneous rocks with magnetite as the magnetic mineral, the coercive forces vary from 10 – 40 mT (Collinson 1983). With an exception of three samples, all the 21 samples investigated are well within this range. These three samples with Hc values in excess of 147.1 mT represent fine-grained ultramafic rocks which have entirely different evolution history. The saturation remanent hysteresis curves of these samples (Fig.4) are similar to those of experimental curves observed on samples of known grain size fractions of magnetite powders (Dankers 1978) and on natural samples (Poornachandra Rao, Chacko & Bhalla, 1992; Poornachandra Rao, Subrahmanyam & Bhalla 1994) confirming the observed coercive forces.

Initial susceptibility of magnetic material depends on a number of factors such as their properties and measuring techniques (Dearing et al. 1996; Moskowitz, Jakson & Kissel 1998). The susceptibility variation with temperature for various compositions of magnetic minerals, their domain states and their mixtures was reported by Radhakrishnamurty & Deutsch (1974), Radhakrishnamurty (1985; 1990), Radhakrishnamurty, Likhite & Sahasrabudhe (1977) and Moskowitz, Jakson & Kissel (1998). With the help of K-T variation behaviour various types of domain states (SD, MD, CD, SP etc.,) and their mixtures (CD+SD, CD+MD, SD+SP etc) of the magnetic mineral in rocks can be distinguished. Results of the K-T studies on alkali rocks are shown in Fig.5 and listed in Table 2. The K-T curves of these samples displayed uniform variation. Broadly two types of susceptibility variation with temperature are noticed in these samples ie., type one reveal susceptibility peak values between 1.07 and 1.47 at a temperature of –156 °C with RS values between 0.56 and 0.98. The other type reveals RS values between 1.04 and 3.0 without any susceptibility peak at –156 °C. These features of the K-T variation indicate that the magnetic mineral in these rocks is in CD+MD and CD domain states respectively (Radhakrishnamurty, Likhite & Sahasrabudhe 1977). All the samples from alkali dyke, ultramafic and carbonatite rocks indicate CD domain state whereas the remaining rocks indicate CD+MD domain state of the magnetic carrier in them.

Table 2: Rockmagnetic Properties of Some Alkali Rocks, Northwest India.

Rock Type	Sp. No.	Jn A/m	K 10^{-3}SI	Qn	Hc mT	Hs mT	Js A/m	RS $K_{-196}\backslash K_{RT}$	SP K_{-156}/K_{RT}
Ultramafic	AL12c	1.57	0.82	48.14	215.4	600	48.6	1.20	1.00
	AL14bII	0.52	0.55	23.86	195.0	700	47.0	1.67	1.00
Carbonatite	AL65bI	0.17	0.62	6.91	29.5	500	8.4	2.40	1.00
	AL69c	0.03	0.27	1.89	147.7	750	19.6	1.56	1.00
Gabbro	AL29bI	7.68	80.36	2.39	37.0	200	45.2	0.93	1.33
	AL31bII	2.44	26.24	2.39	32.4	200	75.8	1.04	1.26
	AL37bI	2.50	48.24	1.26	25.0	250	62.4	0.98	1.25
	AL39bII	2.46	44.01	1.38	22.1	200	61.8	0.89	1.33
	AL55bI	0.79	2.60	6.91	32.5	200	47.5	1.24	1.47
	AL58cI	3.90	77.92	1.26	22.0	200	48.8	0.92	1.35
Lamprophyre	AL71cII	1.45	47.84	1.26	9.6	100	69.7	0.98	1.17
	AL73bII	3.10	66.80	1.26	8.8	100	69.0	0.56	1.16
Syenite	AL6BaII	0.07	2.46	0.75	17.7	200	19.4	1.10	1.25
	AL10bI	4.75	4.65	25.64	24.4	300	43.4	1.22	1.28
	AL51cII	0.06	3.55	0.50	40.0	500	26.6	0.88	1.36
	AL53cII	0.14	4.37	0.75	35.0	500	40.0	0.90	1.33
Basalt	AL41aI	5.12	136.90	0.88	18.5	400	30.3	0.79	1.32
	AL42bII	2.48	12.20	5.15	37.0	500	58.1	0.74	1.26
Dolerite	AL45bII	9.24	38.27	6.03	28.0	200	79.6	0.82	1.07
	AL47aII	60.50	26.79	56.82	16.2	200	17.7	0.79	1.42
Alkali Dyke	AL17aII	0.04	0.55	1.89	40.0	300	9.4	2.67	1.00
	AL22bI	0.07	0.68	2.64	36.7	400	9.2	3.00	1.00
	AL24cI	2.80	32.66	2.14	28.6	300	71.1	0.85	1.03
	AL28bII	0.43	5.45	2.01	35.0	300	74.5	1.08	1.00

Jn = NRM Intensity
K = Susceptibility
Hc = Coercive Force
Hs = Saturating Field
Js = Saturation Intensity
RS = Relative Susceptibility
SP = Susceptibility Peak

Lowrie-Fuller Test is a simple test involving comparison of AF demagnetization intensity decay pattern of NRM and laboratory induced S_{IRM} in rocks (Lowrie & Fuller, 1971). In Fig.6 the NRM and S_{IRM} AF demagnetization spectra are compared for this purpose to infer the domain state of magnetic carrier in these alkali basalts. It may be seen that in almost all cases the NRM demagnetization exhibits a hard behaviour than that of the corresponding S_{IRM} demagnetization curves. Thus this behaviour of the rocks is characteristic of Single Domain (SD) nature of the magnetic carrier in them. However, some samples with coarse grained nature (such as syenite and gabbros) exhibit criss-cross behaviour which may be interpreted as mixed domain states of both Single Domain (SD) and Multi Domain (MD) nature of the magnetic mineral. This interpretation is in agreement with that inferred from K-T studies on these rocks that reveal CD and CD+MD domain states of the magnetic carrier. CD state is nothing but an oxidized version of SD state (Radhakrishnamurty, Likhite & Sahasrabudhe 1977) that give them stable nature of remanent magnetic signature characteristic of fine grained magnetic minerals.

CONCLUSIONS

Thus a magnetic study of alkali rocks associated with Deccan basalt in the western and northern India in the states of Rajastan and Gujarat is successful in identifying the magnetic mineral, its grain size and domain state in them. The wide range of basic magnetic properties are due to variable amounts of magnetic mineral in them without any magnetic and thermal alterations as revealed by laboratory AF and thermal demagnetizations. Both titanomagnetite and magnetite are the important carriers of magnetism in these alkali rocks. The magnetic mineral in these rocks exhibits grain size variation over a wide range as inferred from the observed coercive force (Hc) value of 8.8 to 215.4 mT and high mdf values from 10 mT to >100 mT. The K-T variation study and Lowrie-Fuller tests reveal that the magnetic mineral in them is in the form of CD and CD+MD state of domains which attribute very stable behavior to the magnetic signature in them which enable them to retain it over long geologic periods. The several magnetic property studies under taken on the rocks are mutually corroborative giving a comprehensive picture of magnetic mineral in them.

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