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PETROCHEMICAL STUDY OF REPORTED "ASH BEDS" FROM THE NAGROTA FORMATION (UPPER SIWALIKS), JAMMU REGION

L.N.GUPTA[1], B.L.DHAR[2] AND N.KOCHHAR[1]

1. Department of Geology, Punjab University, Chandigarh.
2. Department of Geology Jammu University, Jammu.

ABSTRACT

Volcanic ash/tuff layers reported from the Nagrota Formation of Jammu region have been reinvestigated. These beds do not contain any identifiable pyroclastic material. On the otherhand, they are composed of components viz. clayey groundmass schistose rock fragments, mineral fragments of quartz, feldspar and biotite, and isolated heavy minerals embedded in the groundmass.

Zircons are of different colours and show smooth surfaces having elongation ratios between 2.5 and 6.0 which suggest that the zircons may have been derived from magmatic rocks like granites and pegmatites. Long thin flakes of biotite suggest their derivation from metamorphic rocks. Subrounded and rounded flakes of biotite (in basal section), and opaques indicate that they have been transported in more than one cycle. Schistose fragments in the rocks substantiate the above contention.

Major and trace element chemistry indicate that the volcanic ash/tuff beds are not true bentonites. They are of granitic or granodioritic composition and their material have been derived from granitic and metamorphic rocks. As such the volcanic activity of Dacht-i-Nawar has no bearing on their genesis.

INTRODUCTION

Yokoyama et al., (1987) identified one bentonitic volcanic ash bed (VA) and one bentonitic volcanic tuff bed (VT) in the Utterbeni-Parmandal section of Jammu region (middle part of Nagrota Formation = Pinjor Formation). The VA is 20-25 cm thick with lateral development for about 2 km. It is coarse grained at the base and fine grained towards the top and has altered to a flesh coloured material which swells when soaked in water. The VT bed (~1 m thick) is extremely fine grained and is glistening white but changes to ash grey colour on moistening. It has lateral extension for about 15 km towards south along the strike of the adjacent beds. The VA and VT beds are interbedded with clay and sandstone and occur at an interval of about 30 m. Both the VA and VT have sharp contacts with the underlying beds and are uncontaminated for most part of their deposition but towards the top they are mixed with other detrital sediments. The younger bed has been recorded from the Nagrota and Balli sections also. The thickest bentonite band in the Nagrota Formation is 3.6 m (Bhat et al., 1999,p.41). Yokoyama et al., (1987), Ranga Rao et al., (1988) Mehta et al., (1993) determined fission track (FT) ages of zircons (separated from the VA/VT beds) between 1.57 0.43 Ma and 2.80 0.56 Ma. On the basis of the FT ages, Yokoyama et al., (1987) (assigned relative ages to vertebrate faunal assemblage of the Upper Siwalik Formation.

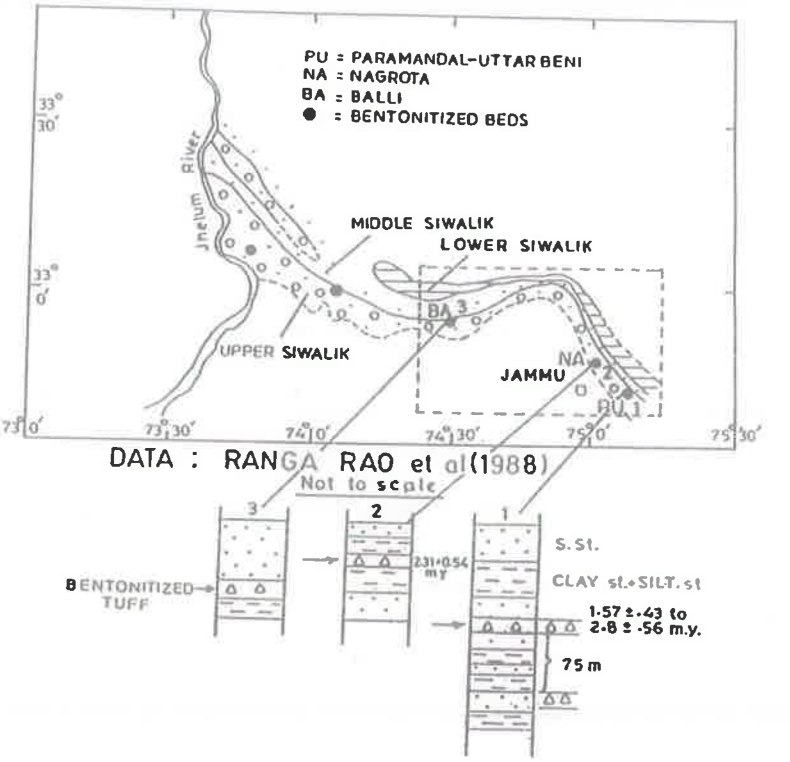


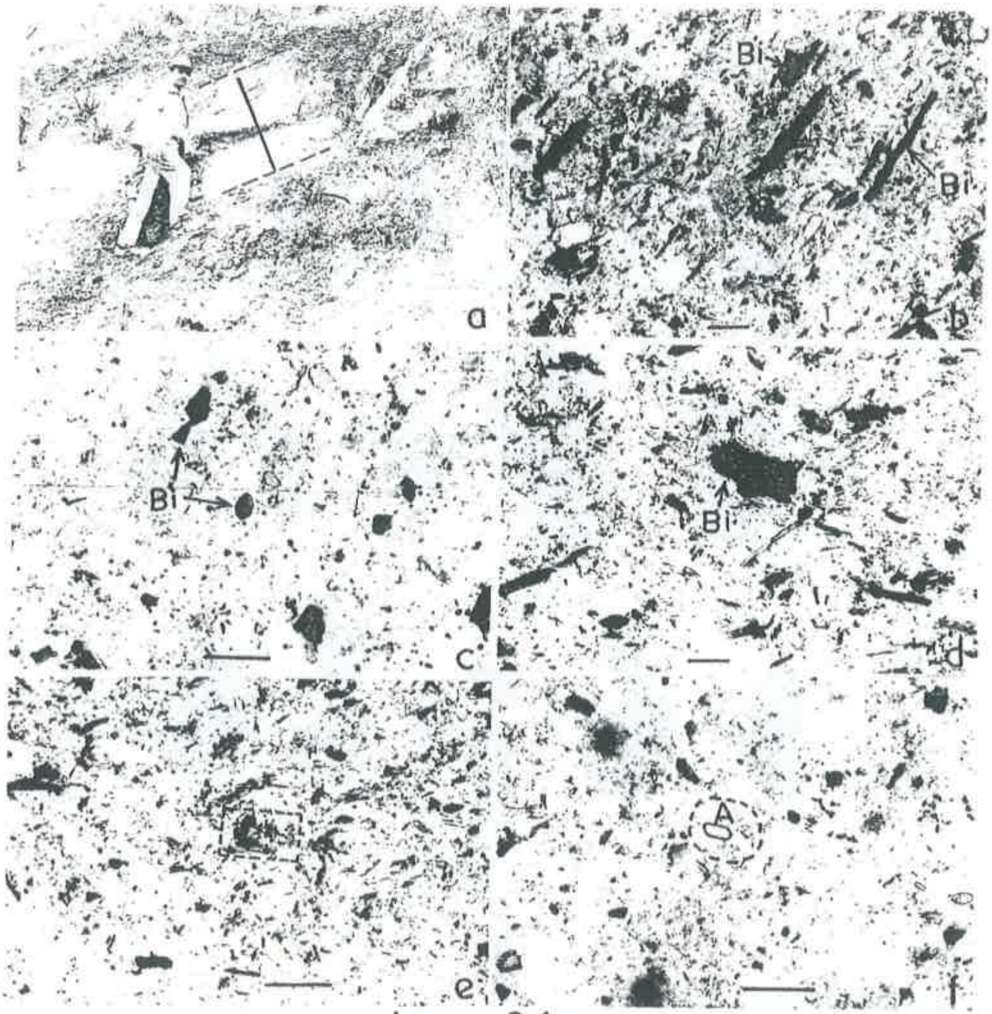
Fig. 1. Sketch map of Upper Siwalik Formation of Jammu region showing location of the reported volcanic ash/tuffaceous beds.

Visser and Johnson (1978), Opdyke et al., (1979), Johnson et al., (1982) and Burbank and Tahirkheli (1985) have reported VA and VT beds from Potwar and Peshawar regions (Pakistan) and in few sections pumice clasts have also been reported. Further, they considered that the material of these VA and VT beds have been derived from Dacht-i-Nawar (East Central Afganistan) volcanic complex. Yokoyama et al.,

EXPLANATION OF PLATE VII

Fig. a. Field photograph showing the horizon of clay bed which has been reported as VA/VT by earlier workers from Nagrota by pass section. Outcrop (approx. 1 m thick) marked with dotted lines.

Fig. b-f. Photomicrographs of thin sections of the reported VA/VT rocks showing (pl. pol.) : b) Alignment of biotite flakes (Bi) which are extremely thin and bent; c) Basal section of rounded biotite (Bi); d) Biotite flake (Bi) showing rounding and disintegration at margins; e) Schistose rock fragment of rectangular shape (marked with dotted line); f) Subrounded apatite crystal embedded in the groundmass (encircled with a dotted line). Horizontal bar shows the scale.



bar = 0.1mm

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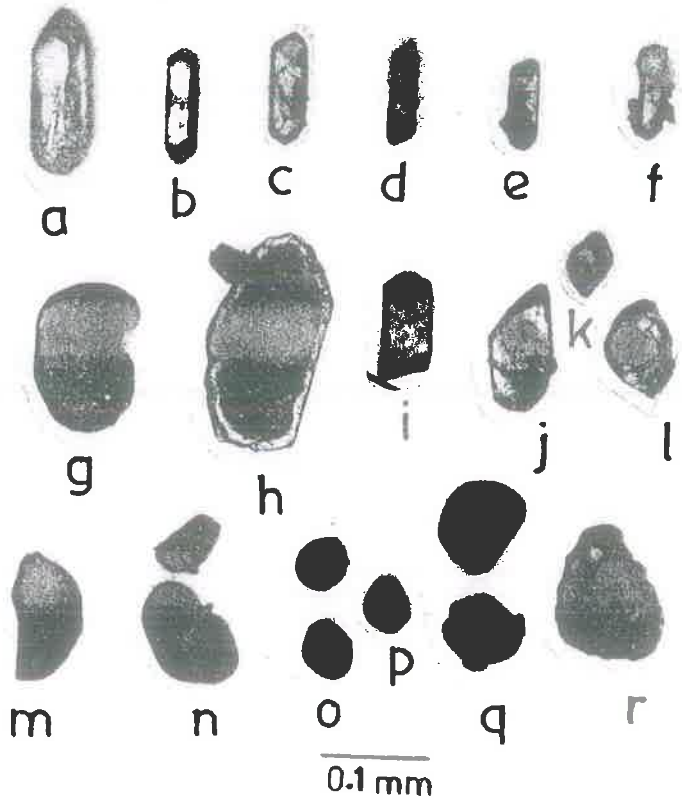
Ash Beds from Nagrote Formation, Jammu



L.N. GUPTE & OTHERS
Ash Beds from Nagrote Formation, Jammu

(1987) observed that there is a physical similarity and stratigraphic analogy of VA and VT beds of Potwar and Peshawar regions with those of the Jammu region. They interpreted that both the VA and VT beds occurring in the latter region are the direct fall of volcanic ash from the Dacht-i-Nawar volcanic complex (around 3.0-1.5 Ma). Subsequently, the VA/VT beds have altered to bentonitised material.

Yokoyama et al., (1987) and subsequent workers recognised the VA and VT beds on the basis of i) colour; ii) bentonitic nature of the beds, iii) abundance of zircon and biotite in the basal portion of these beds; iv) FT age of zircons; v) physical similarity and stratigraphic analogy of beds with those of the Potwar and Peshawar regions. It is important to mention here that none of the above characters is characteristic of pyroclastic origin. So to date vertebrate fossils and to establish chronostratigraphy of the Siwaliks, on the basis of the reported VA/VT beds, could be misleading. Therefore, it was considered necessary to study and examine the reported pyroclastic origin of the VA/VT beds of Jammu region. The results are presented in the following pages.

FIELD AND PETROGRAPHIC DESCRIPTION

Numerous specimens from the clay beds which were considered to be VA/VT of Utterbeni-Parmandal, Nagrota and Balli sections of Jammu region (Fig.1) have been studied. Thin bands (about 2 cm thick) of carbonaceous material are present at the base of the thicker (~ 1 m) VA/VT beds. To avoid contamination, specimens were collected from the middle portion of such beds (Plate VII, Fig. a).

The rocks are greyish white clay with visible specks of biotite flakes and exhibit only little compaction. Under the microscope, the rocks are either clay or siltstone and exhibit a linear structure due to the alignment of thin long biotite flakes (Plate VII, Fig. b). Most of the thin sections are composed of four components namely groundmass, rock fragments, mineral fragments and isolated crystals.

The groundmass is extremely fine grained and is composed of clay minerals and some ferrugineous material. Isolated rounded/subrounded, irregular shaped grains of quartz and rock fragments are embedded in the groundmass. Few crystals of zircon and apatite are also recognisable (Plate VII, Fig. d).

Rock fragments are irregular to subrounded or tabular in shape (Plate VII, Fig.e). They are usually 0.5-1.00 mm long but larger and smaller fragments are also

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EXPLANATION OF PLATE VIII

Fig.3 Photomicrographs of heavy minerals: a-f) Idiomorphic or subidiomorphic zircons. Crystals a and c contain inclusions of zircons; g) rounded biotite; h) Biotite showing rounding at one corner and also shows disintegration; i) Tourmaline; j) Subangular to subrounded topaz; k-1) subrounded epidotes; m-r) Subrounded to rounded opaque grains.

present. Though the minerals in these fragments are completely altered yet they retain their shape. It is inferred that most of the fragments are of schistose rocks in which the micaceous minerals have altered to chlorite and opaques are concentrated in patches. Hence a part of the material of the beds under study has been derived from metamorphic rocks.

Biotite flakes (pleochroic from greenish yellow to greenish brown) are more or less aligned in a particular direction and are usually bent (Plate VII, Figs. b,d). Biotite constitutes about 2-3 vol.% of the rock. Most common dimensions of biotite flakes are 0.2-0.4 mm 0.02-0.04 mm but larger and smaller flakes are also present. Biotite flakes have elongation ratio upto 20 which suggests that they were derived from schistose rocks (Tyrrell, 1980). These flakes exhibit distintegration at the margins (Plate VII, Fig. d, e) resulting in the leaching of brown colour to the groundmas and leave the skelatal relics of biotite. At the ends, many flakes are sub-rounded to rounded (Plate VII, Fig. d) and this effect is seen quite prominently in the basal sections of biotite (Plate VIII, Fig. c, Plate VIII, Fig. g & h). This indicates that biotite has become rounded or subrounded during the process of transportation and sedimentation. Occasionally tiny crystals of zircon and apatite are enclosed in the biotite flakes.

Quartz fragments are common and constitute about 2 vol.% of the groundmass. They are of various shapes and sizes e.g. angular to subrounded, irregular. Usually, they show undulose extinction. Feldspars are usually altered and only their relicts are recognised.

HEAVY MINERALS

Heavy minerals have been separated using usual gravity separation techniques. Biotite, zircon, kyanite, epidote, rutile, tonaz, muscovite, and opaques were recognised amongst the heavy mineral crops of all the analysed samples.

Most of the zircons are bipyramidal shape and of slender and prismatic type (Plate VIII, Fig. a-f). About 70% of the crystals are idiomorphic and exhibit the development of all the faces at both the ends. The rest shows little rounding of the faces at one extremity or termination of the crystals. Zircons are pink or pinkish pale or colourless and the coloured varieties are feebly pleochroic. Occassionally, inclusions of slender zircons are enclosed in the main crystal (Plate VIII, Fig. a). Sometimes transverse cracks are also present. Zircon length vary from 0.07 to 0.14 mm. The elongation ratios (ER) vary from 2.5 to 6.0 but majority of zircons have ERs between 2.5 and 3.0.

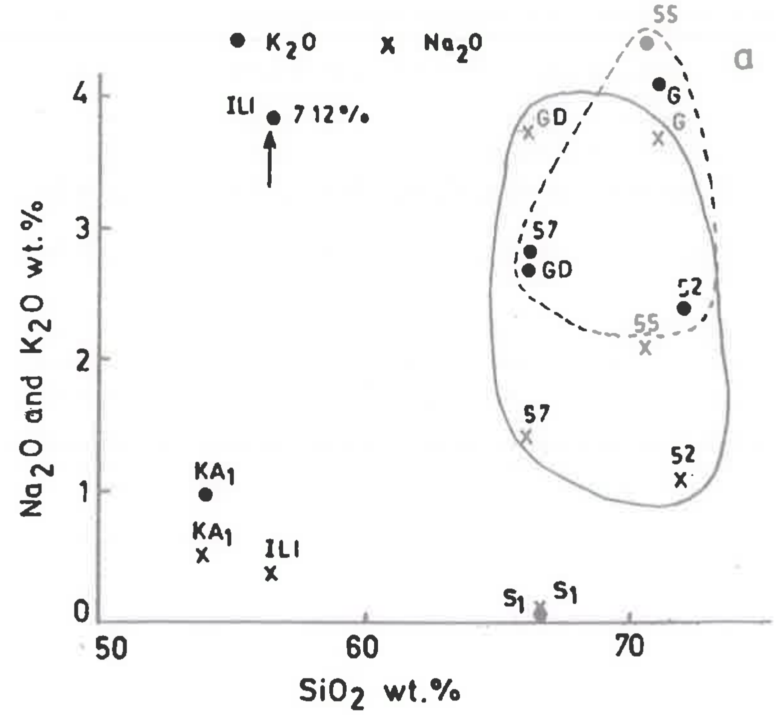
Idiomorphic or subidiomorphic zircon crystals of different colours with smooth surfaces having elongation ratios between 2.5 and 6.0 suggest that the zircons may have been derived from more than one source and their parent rocks may be of plutonic origin. The rocks may be of granitic or pegmatitic or late granitic composition (Brindley and Gupta, 1973). Under these circumstances, the FT ages on single zircon crystal have no bearing on the chronostratigraphy established in the region.

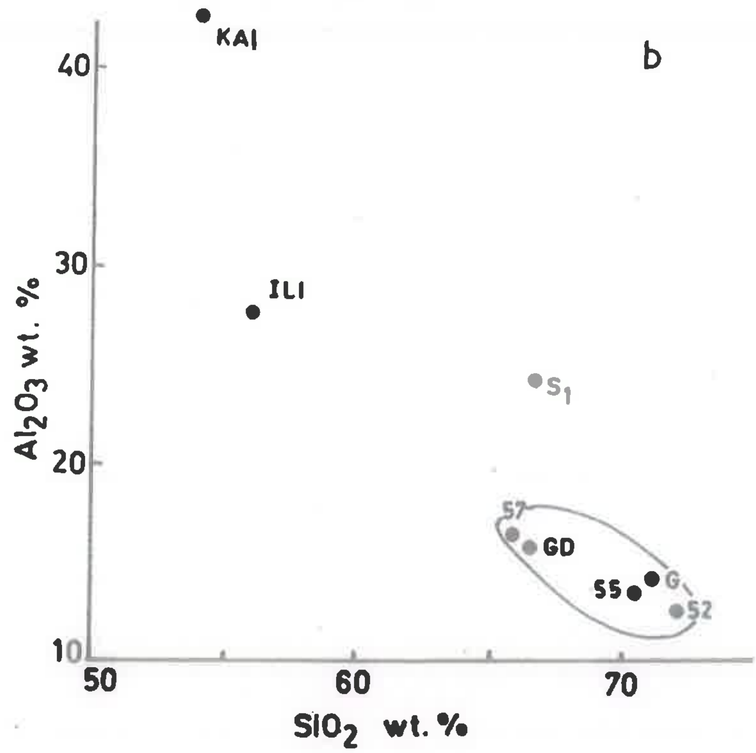
Table 1: Major and Trace element data for the reported VA/VT beds of Jammu region

Sp.No.	52	55	57	G	GD	KA1	S1	IL1
SiO_2	71.75	70.49	65.93	71.30	66.09	53.88	66.66	56.67
TiO_2	0.67	0.26	0.27	0.31	0.54	0.21	-	0.40
Al_2O_3	12.79	13.89	16.03	14.32	15.73	42.97	24.29	28.05
MnO	0.07	0.06	0.06	0.05	0.08	-	-	-
Fe_2O_3	4.92	1.80	2.02	30.1	4.38	0.74	0.07	4.38
MgO	2.07	0.79	2.90	0.71	1.74	0.30	4.86	2.92
CaO	0.90	1.78	1.93	1.84	3.83	0.32	4.20	0.65
Na_2O	1.04	2.09	1.42	3.68	3.75	0.51	-	0.35
K_2O	2.40	4.38	2.81	4.07	2.73	0.97	-	7.12
P_2O_5	0.15	0.07	0.05	0.12	0.18	*	*	*
Trace elements				PC93	PC101			
Ba	434	732	726	416	487			
Ce	62	16	35	nd	nd			
Co	23	nd	nd	20	24			
Cr	73	nd	nd	20	24			
Cu	19	1	2	8	10			
La	43	2	nd	nd	nd			
Nb	10	7	4	17	16			
Ni	39	4	5	31	25			
Ga	14	22	23	11	30			
Pb	20	24	39	50	44			
Pr	1	3	7	nd	nd			
Rb	128	160	78	251	173			
Sr	105	221	214	120	153			
Th	17	12	13	21	27			
V	86	25	26	24	27			
Y	30	10	10	53	47			
Zr	219	87	78	167	223			
Zn	72	52	67	50	61			

52, 55 & 57 - Reported VA/VT beds of Jammu region have been analysed after drying the samples at 105^0C. G-granite, GD-granodiorite (Best, 1986,p.612 & 613), FeO is converted into Fe_2O_3 for uniformity sake; * - K-A1-Kaolinite, S1-Smectite, IL1-Illite (Grim, 1968,p.576, 578 & 580) contain 12.95, 22.21 and 7.88 wt.% of total water respectively. This water has been distributed proportionally amongst all the oxides to make the analyses compatible for comparison with those of the Jammu region.

Specimens PC93 and PC 101 are granitic rocks of the Dhauladhar Range (Lesser Himalaya) and were analysed on XRF at UCD, Dublin by Dr.R.Elsdon.


K2O
Na2O
a
ILI
7.12%
GD
G
S5
S7
S2
KA1
S1
Na2O and K2O wt.%
SiO2 wt.%
0
1
2
3
4
50
60
70


KAI
b
ILI
S1
S7
GD
S5
G
S2
Al2O3 wt. %
SiO2 wt. %
10
20
30
40
50
60
70

Toumaline (Plate VIII, Fig. i), rutile, kyanite, topaz (Plate VIII, Fig.j), epidote (Plate VIII, Fig.k-1), show usual optical characters and exhibit various degree of roundness. The opaques are abundant in the heavy fraction (Plate VIII, Fig. m-r). Smaller grains are subrounded to well rounded (Plate VIII, Fig. o). Larger opaque grains are irregular to subrounded (Plate VIII, Fig. q-r). The morphological characters indicate detrital origin of these minerals.

CHEMICAL ANALYSIS

Three rock specimens from the reported VA/VT beds of Jammu region have been analysed by XRF for major and trace elements (Table 1). Bivariant plots of SiO_2 vs K_2O and Na_2O and SiO_2 vs Al_2O_3 show that the analysed VA/VT samples fall in the field of granite/granodiorite (Figs. 4a, b). For comparison, minerals of bentonite group i.e. kaolinite, smectite and illite are also shown. A perusal of the figures shows that the analysed samples are quite distinct from those of the bentonite group of minerals. When the data of these samples were plotted on the Y vs Nb diagram (Pearce et al., 1984), they fall in the field of VAG+syn COLG granites. High values of Ba and Rb and paucity of Ni, Cu, Cr and Co in the analysed rocks suggest that the material for these rocks has been derived from the acidic rocks. Thus the chemical data of these rocks do not indicate any relation with the andesitic rocks of the Dacht-i-Nawar (cf. de Lapparent and Bordet, 1963).

DISCUSSION AND CONCLUSIONS

Tandon and Kumar (1984), Raghavan (1990) and Patnaik (1995) reported the occurrence of tuffaceous mudstone beds from Ghaggar river section (Pinjor) and compared these beds with those of the VA/VT beds of Jammu region. Gupta (1996a and b) concluded that the reported tuffaceous mudstone beds neither contain any recognisable volcanic material nor exhibit any volcanic texture. Morphological characters of biotite, zircon and opaques indicate that a major proportion of these minerals is of detrital origin. Mathur et al., (1996) identified thin volcanic ash beds at the contact of Dagshai and Kasauli Formations (Tertiary) on the basis of SEM micrographs. the identification of volcanic shards/tephra on SEM micrographs appear to be doubtful as the magnification is of the order of 500 times.

The work of Katsi (1963) shows that the thickness of a VA/VT bed is directly proportional to the distance of the source rock. Dacht-i-Nawar is about 700 km away from the so called VA/VT beds of Jammu region. If this distance is extrapolated on the diagram of Katsui (1963), thickness of the VA/VT bed of the Jammu region should not be more than few centimetres (Fig. 5). But the VA/VT beds in some sections under study, are upto 3.6m thick and hence the data does not corroborate with the observed

Fig. 4 a & b Variation diagrams : a) SiO_2 wt.% vs K_2O and Na_2O wt.% and SiO_2 wt.% vs Al_2O_3 wt.% show that the analysed rocks fall in the granite/granodiorite field and are distinctly different from minerals of bentonite group. For explanation of specimen numbers see Table 1.

occurrences mentioned by Katsui (1963). Therefore, the Dacht-i-Nawar igneous complex cannot be considered as the source of such beds.

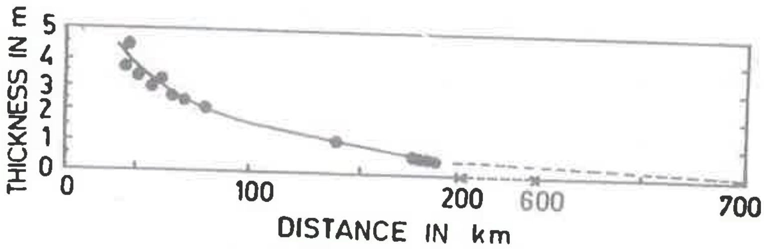


Fig. 5 Distance vs thickness of the VA/VT beds extrapolated to a distance of 700 km.

The different FT ages from the same stratigraphic horizon reported by various workers (see above) but on different crystals of zircon suggest that the zircons were derived from different sources. Hence, it is concluded that the reported VA/VT beds of Jammu region are simply clay/siltstone beds of sedimentary origin. Therefore, the FT ages have no bearing on the age of these beds and as such of no consequence to the faunal dispersion.

The field relationships, petrography, heavy mineral studies and geochemical investigations indicate that, i) the material of the reported VA/VT beds under study have been derived by the sedimentary process, ii) there is no pyroclastic material in these beds, iii) the clay nature of the beds is due to the depositional and environmental factors, iv) volcanic activity in the Dacht-i-Nawar igneous complex has no bearing on the deposition of the clay beds, and v) FT ages of zircons in the present case has no relevance with the Dacht-i-Nawar volcanic activity. It is, therefore, suggested that the stratigraphers and palaeontologists should re-examine such beds elsewhere in the Himalaya

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