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PALAEOSOLS WITHIN LOESS: DATING PALAEOCLIMATIC EVENTS IN KASHMIR

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ABSTRACT. The ^{14}C dates of Kashmir loess-palaeosols form five clusters. The dates, mineral magnetic, stable isotopic, and pollen data help decipher major climatic oscillations as distinct from the minor ones.

Loess deposits in India have so far been reported mainly from Kashmir and the Son Valley in Uttar Pradesh. In Pakistan, the Potwar Plateau also has significant thickness of loess deposits. In Kashmir loess forms the top-most mantle of the sedimentary profile which starts at ca 4.0m yr (Kusumgar, 1980). The maximum thickness of loess in the Kashmir Valley is ca 25m in the Southwest diminishing to ca 10m in the Northeast. As loess sits unconformably over the eroded surface of the Upper Karewas, the bottom of the loess profile follows an undulating topography. As none of the lake pollen profiles examined so far go beyond 20,000 BP, the loess profiles assume greater significance as a record of climatic events.

Loess is predominantly a silt-sized (5 to 50μm) alkaline, amorphous sediment deposited through aeolian agencies in peri-glacial regions. In cold and arid climate, loess does not weather much. However, during milder climatic ameliorations (interstadials), some incipient pedogenesis does take place; full soil development is the result of generally warmer and humid conditions (interglacials). Due to the porosity and alkalinity of loess, pollen is generally not preserved, necessitating a search for other palaeoclimatic indicators.

We have detected nine buried soils (palaeosols) in the Kashmir loess profile. The problem was to date the sequence of palaeosols to determine how many soils exist and how many represent major climatic oscillations. The ^{14}C technique was used for dating and to distinguish soils representing significant climatic warming (interglacial type conditions). For milder climatic variations (interstadial type conditions), mineral magnetic, stable isotopic, and other parameters were used.

Figure 1 shows the sites dated and Table 1 shows their ^{14}C dates. Thirty ^{14}C dates were obtained from ca 14 sites that fall into 5 clusters. Table 2 clearly shows that five soils formed during the period covered by the ^{14}C dating range.

We will first discuss the climatic sequence derived from the pollen profiles of the main bogs of Kashmir. At Butapathri I and II we observe a distinct climatic amelioration at 18,000 yr BP marked by the partial dominance of the broad-leaved groups such as *Ulmus, Alnus, Juglans* (Dodia, Agrawal & Vora, 1985). A climatic amelioration occurs at Anchar at ca 5000 BP accompanied by an anthropogenic impact on the ecology in the form of *Cerealia, Plantago* pollen (Dodia, Agrawal & Vora, 1985). In the ^{14}C dates cluster of palaeosols we do get well-developed soils at ca 5000 ± 1000 BP and ca 18,000 ± 1500 BP.

TABLE 1

^{14}C dates on the half-life, 5568 ± 30 yr, on organic matter of palaeosols from loessic deposits in the Kashmir Valley

Tsrar Sharif (33°51′N, 74°46′E)7*	Pakharpura (33°48′N, 44°47′E)7*	Romu (33°53′N, 74°50′E)7*	Zadur (33°55′N, 74°51′E)7*	Karpura (33°50′N, 74°47′E)9*	Malpura (33°54′N, 74°49′E)8*	Tilsur (33°52′N, 74°47′E)5*
		4030 ± 130 (630)**		5930 ± 170 (848)	6500 ± 190 (851)	
		5660 ± 120 (629)				
			15,360 ± 360 (635)			
						$20,740^{+1050}_{-980}$ (850)
	$27,630^{+1350}_{-1160}$ (627)		$26,660^{+1240}_{-1070}$ (636)	$25,190^{+1740}_{-1430}$ (849)		
>31,000 (625,626)	>31,000 (628)					
Dilpur (33°56′N, 74°57′E)5*	**Pythpatan (34°12′N, 74°21′E)3***	**Puthka (34°14′N, 74°21′E)3***	**Burzahom (34°10′N, 74°53′E)3***	**Garhi Burzahom (34°10′N, 74°53′E)3***	**Olchibagh (33°57′N, 74°56′E)3***	**Saki Paparian (33°49′N, 75°7′E)3***
	4190 ± 140 (816)					
14,490 ± 310 (825)					$12,560^{+450}_{-430}$ (598)	
$17,740^{+630}_{-580}$ (830)		$18,550^{+600}_{-550}$ (618)	$18,890^{+830}_{-750}$ (593)			
			$18,460^{+820}_{-740}$ (590)			
		$25,800^{+1110}_{-960}$ (617)		$26,340^{+2010}_{-1610}$ (592)		
>31,000 (760)			>31,000 (585,596,496)			>31,000 (596)

* Number of palaeosols at the site
** Number in parentheses is PRL ref no.

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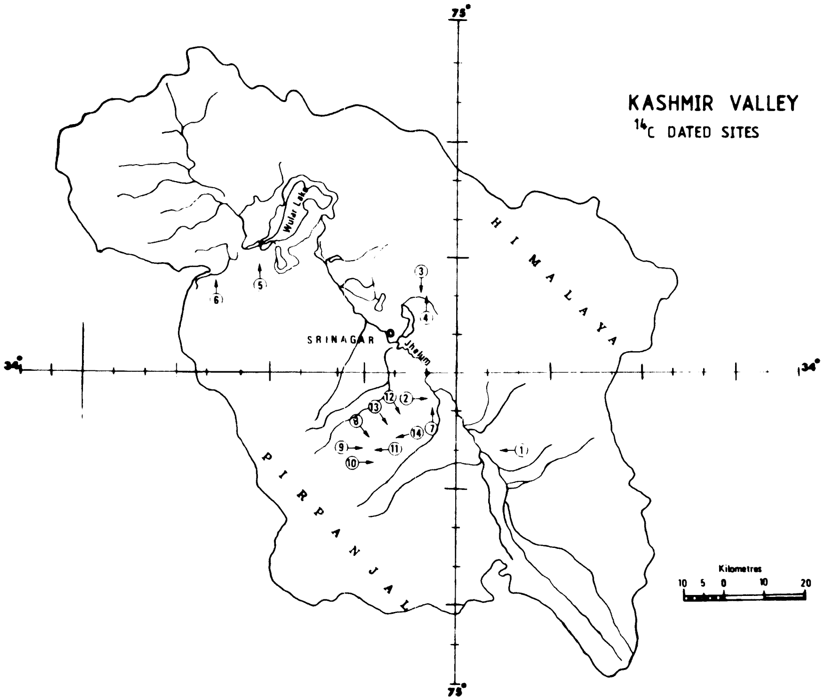

Fig 1. Map of Kashmir Valley with ^{14}C dated sites: 1. Saki Paparian 2. Olchibagh 3. Burzahom 4. Garhi Burzahom 5. Puthka 6. Pythpatan 7. Dilpur 8. Tilsur 9. Tsrar-Sharif 10. Pakhurpura 11. Romu 12. Zadur 13. Malpura 14. Karpura

Krishnamurthy, DeNiro and Pant (1982) used δ^{13}C to monitor climatic change in these soils. This is based on the fact that soils are formed due to vegetal decay and therefore should provide signatures of the types of plants that gave rise to the soils in question. Plants using C_3 photosynthetic pathways have $\delta^{13}C = -27‰$, whereas C_4 type plants have $-14‰$. It was found, eg, that the ca 18,000 BP soil had an organic fraction with $-25‰$ δ^{13}C, which is indicative of C_3 type of plants that thrive under climatically optimal conditions. Thus, this was an additional indication of climatic amelioration at ca 18,000 BP (Krishnamurthy, DeNiro & Pant, 1982).

Pedogenesis induces changes in the magnetic properties of soils due to hematite-magnetite transformation and reduction in magnetic mineral grain size (F Oldfield, pers commun). Magnetic susceptibility (χ) reflects

TABLE 2

The five clusters of ^{14}C dates of the Kashmir palaeosols

1.	ca 5000 ± 1000 yr BP
2.	ca 13,500 ± 1500 yr BP
3.	ca 18,000 ± 1500 yr BP
4.	ca 25,000 ± 2000 yr BP
5.	ca > 31,000 yr BP

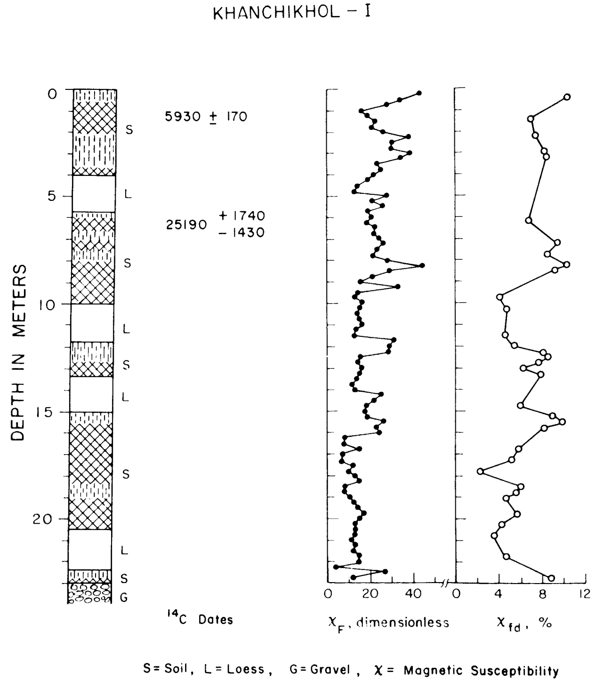

Fig 2. Magnetic susceptibility variation in Khanchi Kol-I, and ^{14}C dates

hematite-magnetite change, the latter having higher susceptibility. The frequency-dependent susceptibility (χ_{fd}), however, depends on grain size. Intense weathering, induced by climatic change, causes hematite to change to magnetite and reduction in grain size, resulting in enhancement of susceptibility (both χ and χ_{fd}). Thus, mineral magnetic markers were used to determine the intensity of weathering; hence, climatic change in different

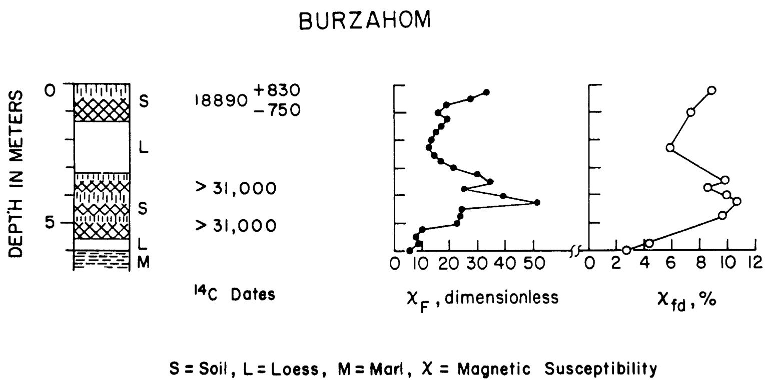

Fig 3. Magnetic susceptibility variation in Burzahom and ^{14}C dates

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palaeosols. Figure 2 shows that though there are 9 soil horizons in Khanchi Kol I, only 5 give a distinct mineral magnetic signal in terms of χ, χ_{fd} values. The different loess profiles that have been ^{14}C dated show that, among the 5 palaeosols, only those dated to ca 5000, ca 18,000, and >31,000 BP, represent major climatic oscillations (interglacial type conditions). At Burzahom (Fig 3), major climatic oscillations have also been observed in the palaeosols dated to ca 18,000 yr and >31,000 yr BP.

Thus, we find that by resolving the total number of the palaeosols to 5 (for the upper part of the loess), we have been able to date the major climatic events reflected by well-developed soils. The different parameters used to detect the signatures of climatic change–like pollen, $\delta^{13}C$, and χ, χ_{fd}–provide definite clues to delineate and date the major climatic events in the Kashmir Valley.

On the basis of available ^{14}C dates and other data from Kashmir (Agrawal *et al,* 1979, 1985) we can estimate the rate of loess deposit. It appears that the loess-palaeosol deposit of Kashmir is younger than ca 100,000 yr BP and, on an average, the maximum interval between two soils is ca 7000 yr. Thus, the rate of deposition of the Kashmir loess comes to 26.0cm/1000 yr compared to 13.0cm/1000 yr for Central Asia (Davis, Ranov & Dodonov, 1980) and 7.0cm/1000 yr for Chinese loess (Tungsheng *et al,* 1985).

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