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CONFIRMING THE PRESENCE OF PALAEOCHANNELS IN WESTERN PART OF JAISALMER DISTRICT, RAJASTHAN THROUGH INTEGRATION OF SPACE AND GROUND METHODS

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Search for palaeochannels in western Rajasthan has been of great scientific interest. The search has been significant for locating sources of good quality ground water in the water scarce western Rajasthan where most of the available sources suffer from poor water quality. Search for Palaeo River Saraswati described in the Vedic literature has also been a major cause for these studies. Remote sensing data from satellites and aerial cameras has been used by several workers to map the palaeochannels. Confirmation of the existence of palaeochannels and establishment of their ground water potential needs further investigation by geophysical and drilling methods. Investigations on the palaeochannels in Western Rajasthan for their ground water significance has been taken up under a multi-institutional collaborative project, "Reconstruction of Palaeo-Drainage Network in Western Rajasthan" to (1) delineate palaeochannels accurately and (2) to assist in selection of sites for geophysical survey and drilling. Detailed analysis of multi sensor remote sensing data from WIFS, LISS-I, LISS-III and PAN sensors onboard Indian Remote Sensing Satellites IRS-1A/1B and 1D has been carried out applying digital analysis techniques. Digital analysis of satellite data in conjunction with the high-resolution capability of PAN and LISS-III sensors helped refining the palaeo river courses mapped earlier. Digital analysis also helped further delineation of narrower anomalies within the broad palaeochannels for ground exploration. The drilling work under the project was undertaken to explore the palaeochannels in the Jaisalmer district in the first phase of the project. Drilling work at fourteen locations in Dharmikhu - Kuriaberi - Ghantiyali - Ranau - Longewala - Ghotaru sections, and the radiocarbon age analysis of the water samples confirm the presence of palaeochannels along 180 km distance and also the occurrence of good quality drinking water along these palaeochannels.

Key Words: Palaeochannels; Sarasvati; Groundwater; Geomorphology; Rajasthan; Thar Desert; Remote Sensing

Introduction

The Thar Desert in Rajasthan exists in western part of the state and occupies an area of 0.2 M sqkm i.e. 57.3% of the total area of the state. It has been conjectured that sometime in the past the desert was a green land recharged by a very mighty Himalayan river 'Saraswati' flowing through western Rajasthan and meeting Arabian Sea. Saraswati is described as a mighty and holy river of India in the Vedic period literature like Rigveda, Yajurveda, Ramayana, Mahabharta and Upanishads etc.[1]. The river became extinct about 1500-2000 BC[2,3]. In a bid to unearth the course of lost river and its tributaries and utilize the buried courses of the lost river for meeting fresh water demand in the water scarce desert terrain, numerous agencies/workers[4-16] have mapped palaeochannels and collected relevant field evidences confirming their presence below the ground. Mapping of palaeochannels involved considerable extrapolations in the gap areas and the ground existence of palaeochannels along the delineated/ proposed courses in sand/dune covered areas could not be confirmed[17].

Exploration of Palaeochannels mapped from remote sensing in Western Rajasthan was taken up under a collaborative project "Reconstruction of Palaeo-Drainage Network in Western Rajasthan" involving, Rajasthan Ground Water Department (GWD)-Jodhpur, the Regional Remote Sensing Service Centre (RRSSC)-Jodhpur, the Bhabha Atomic Research Centre (BARC) -Bombay and the Central Ground Water Board

(CGWB). The project aims at exploring the palaeochannels by geophysical surveys and drilling in the regions delineated with the help of remote sensing. In the first phase of the project, the exploration of palaeochannels in the western part of Jaisalmer district was carried out along the 180 km long section comprising Dharmikhu - Kuriaberi - Ghantiyal - Ranau - Longewala – Ghotaru. Detailed remote sensing studies was carried out to assist the selection of sites for geophysical surveys and drilling. These studies brought out many new features of palaeochannels in Jaisalmer district that were missed in earlier mapping missions, primarily due to lack of high-resolution data[18].

Methodology

Mapping of palaeochannels using multi sensor remote sensing data from WIFS, LISS-I, LISS-III and PAN sensors from Indian remote Sensing Satellites IRS - 1B and 1D was carried out using digital image processing techniques. The digital image processing was carried out on IBM RISC SYSTEM/ 6000 using EASI/ PACE (Engg. Analysis & Scientific Interface/ Picture Analysis Correction & Enhancement) digital image processing software. Spectral merging of PAN sensor data (5.8 meter spatial resolution) was performed with the 23.5-meter resolution LISS-III sensor data for part of the study area covered in the Jaisalmer district (Fig.1). For hybrid product generation, the already registered IRS LISS-III data was co-registered with IRS PAN data using image-to-image registration in GCP works module of EASI/PACE. A 3 X 3 F-Sharp filter was run on the registered PAN data. The PAN + LISS-III hybrid product was obtained by applying an arithmetic model, wherein the enhanced PAN and first three bands of LISS-III data were merged in the ratio of 30:70. Scene No. 90-52 of November 1, 1996 was used. The FCC hard copy products were generated on 1: 50,000 and 1: 25,000 scales for the selected areas around Kishangarh, Dharmikhu and Tanot. In the absence of detailed maps 1:25,000 scale images were used for site selections. These images showed details of sand dunes up to individual sand dune level. The courses of palaeochannels in Jaisalmer district delineated earlier through LISS-I data were refined using merged data products. Field trips were conducted to verify the interpretations. Digital mosaic of the LISS I data was made for most part of the Sarasvati river basin comprising of western Rajasthan and the adjoining parts of Pakistan. Piece wise linear stretching was applied over the mosaiced data that highlighted the buried palaeochannels of Sarasvati to a level that was discernible without any instrumental aids (Fig. 2).

Preliminary selection of sites for geophysical surveys was carried out along the palaeochannels (delineated from satellite imageries) based on accessibility of the sites for geophysical surveys/ drilling. Resistivity surveys using Schlumberger configuration were carried out for the selected sites. The sites found suitable based on geophysical surveys were finally taken up for drilling. Fig. 3 shows a geo-electrical cross section of Tanot-Ghantiyali cross section, that indicates the presence of riverine sediment horizons of (1) medium-coarse grained sands and (2) sands mixed with clay, at varying depths. The thickness of these horizon increases at approx. 1.5 kms, 4.5 kms and 7 kms distance from Tanot and indicated zones favourable for the occurrence of ground water and possible palaeochannels? Drilling has been conducted at fourteen places, in six places by the CGWB and at eight places by the GWD. Drillings have been carried out at Kuriaberi, Nathura-Bera, Ghantiyali, Karthai, Ranau (2 locations), at seven locations between Ghotaru and Longewala (five locations) and one location between Ghotaru and Asutar using. For Kuriaberi, Ghantiyali, Nathurabera, Karthai and Ranau I & II, core recovery could not be done, for rest of the 8 locations the core was recovered during drilling. The drilling was restricted mainly to the alluvial zone and ranged from 100-150 m. The water samples from drilled wells were collected for radio carbon dating at BARC. Table I provides the drilling data and the results of water quality analysis.

Results and Discussion

Digital analysis of a combination of satellite data along with the high resolution capability of PAN and LISS-III sensors provided true shape and orientation of the palaeochannels. The palaeochannels in Jaisalmer district are located around Dharmikhu-Dost Mohammad-Kishangarh-Kuriaberi-Nathurabera-Tanot-Ghantiyali-Ranau-Longewala-Ghotaru areas. It has been noticed that many of the palaeo channel features picked up in the digitally processed high resolution data (Pan + LISS-III merged data) were not visible on low resolution data viz. LISS-I and LISS-III data. High resolution data helped selection of sites on palaeochannels for geophysical investigation and drilling. It was also noticed that the merged data could be enlarged only up to 1 : 25,000 scale as further enlargement resulted in pixel breaks.

Fig. 1 IRS 1C PAN + LISS-III hybrid image of western part of Jaisalmer district

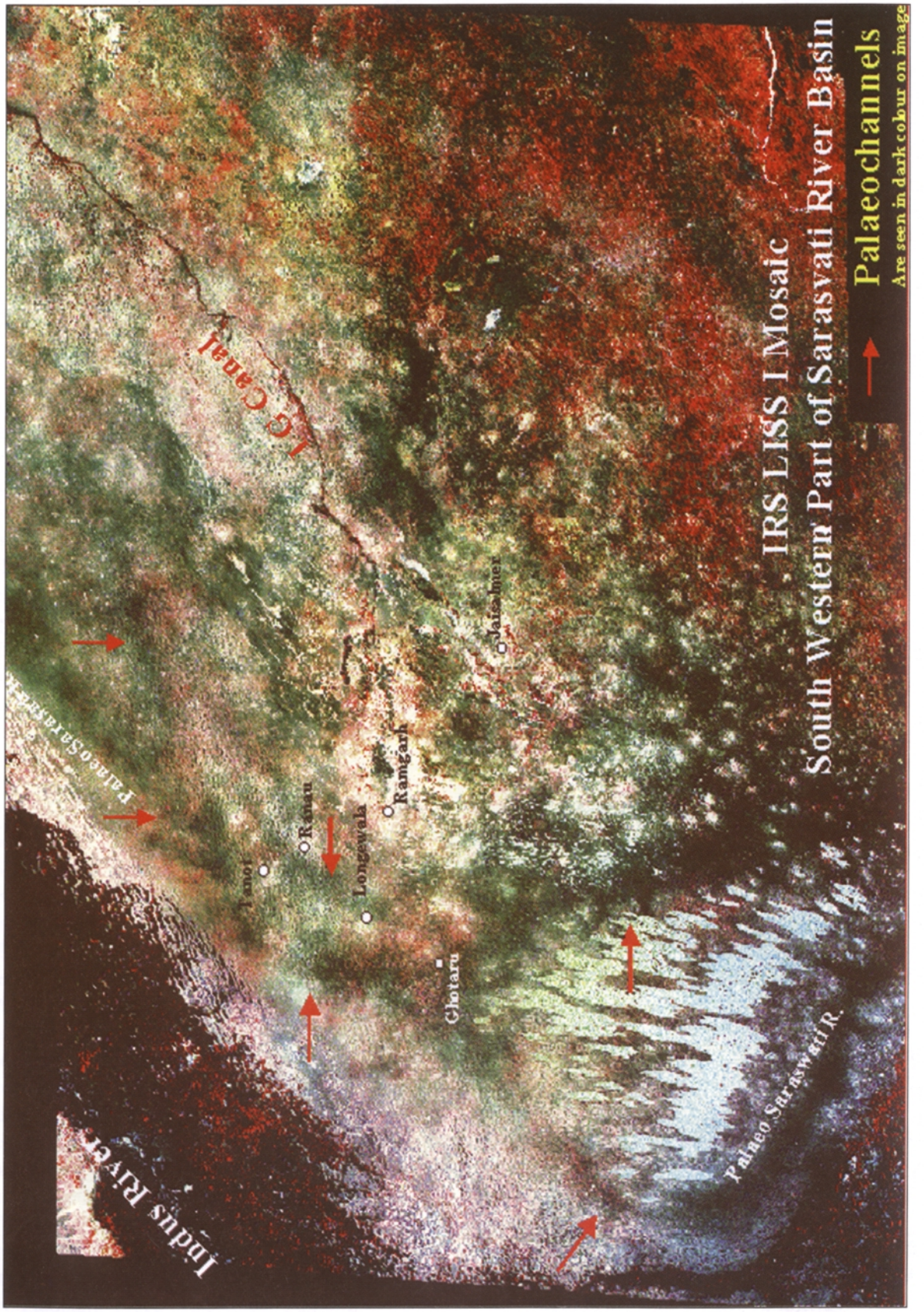

Fig.2 IRS -1B LISS-I digital mosaic of south western part of Sarasvati River Basin

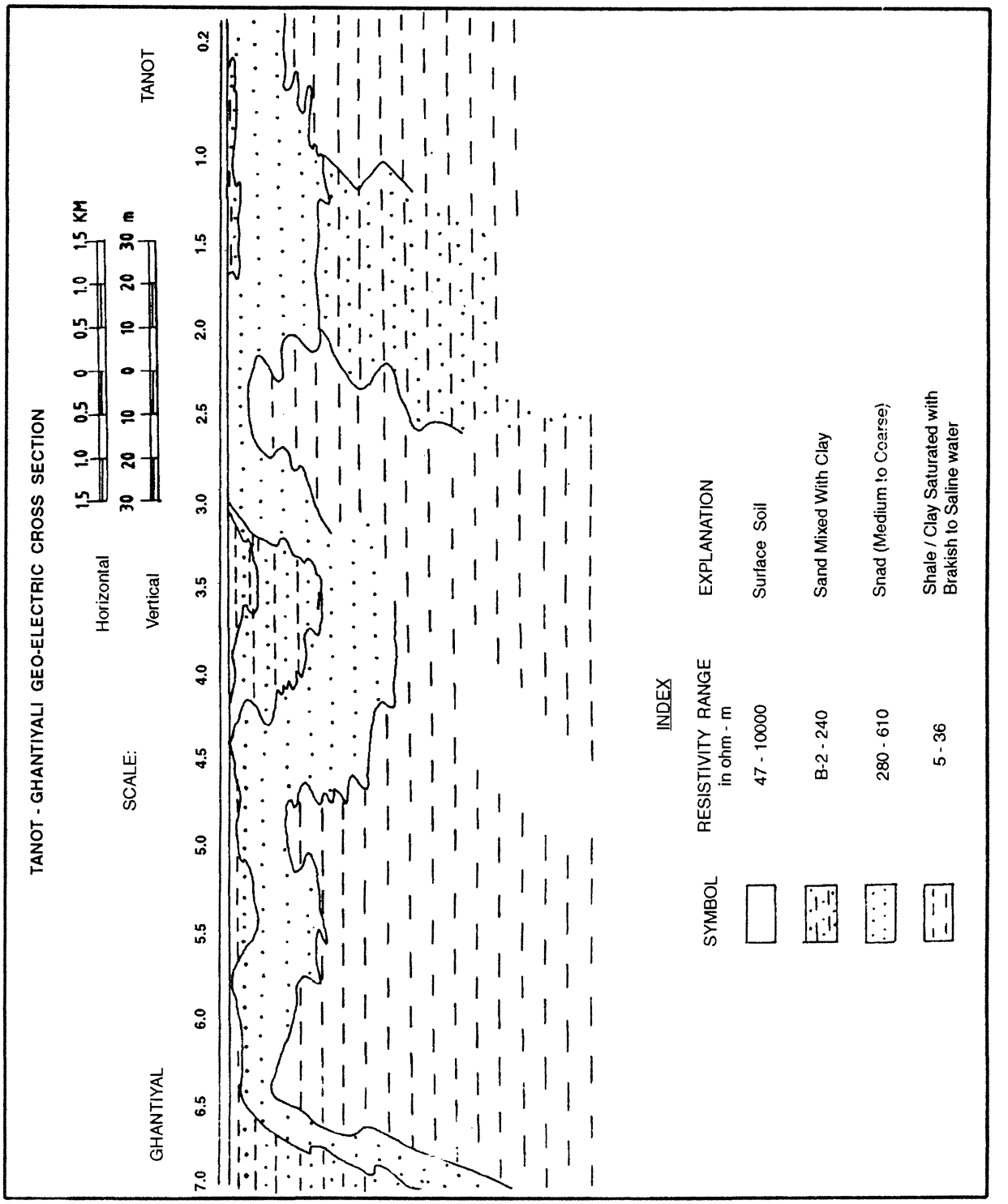

Fig. 3 Tanot - Ghantiyali geoelectrical cross section

The digital merging of PAN and LISS-III data has helped delineation of sub-channel anomalies within the broad palaeochannels (Corn Cob structures) (Fig. 1). Corn-cob structures are formed due to deposition of sand over a flowing water body. Flowing water tries to remove depositing sand load and in the process a different kind of dune pattern comprising of much smaller dunes in larger dune fields along the existing water bodies emerges. On imagery, the Corncob structure appears like scattered corn grains,

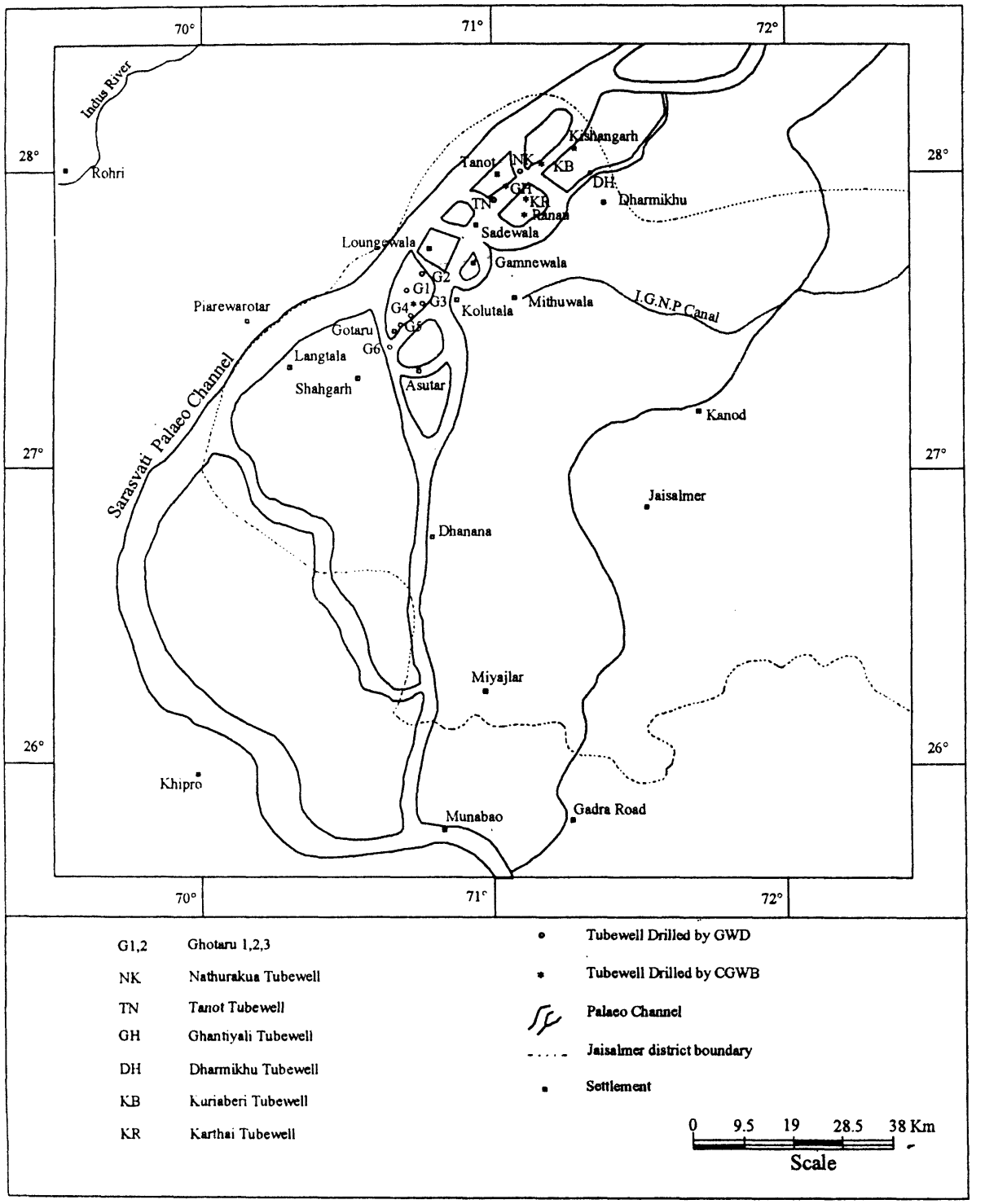

Fig. 4 Locations of borewells drilled in palaeo course of river Sarasvati, mapped from remote sensing data in the Jaisalmer district

Table I

Data of the tube wells drilled on the palaeo channels in the Jaisalmer district
(Source : Ground Water Department, Government of Rajasthan, Jodhpur)

Sl. No.	Drilled Site	Year of Construction	Yield (lph)	Quality (EC) TDS figs. in brackets	Depth Drilled (m)	Static Water Level (m)	Structure Installed	Aquifer material as observed in litholog s
1	Tanot 3.5 Km from Ghantiyali to Tanot LHS of Road	1999-2000	11250 by compressor	4400 (2650)	125	33	Tubewell	Mainly fine grained sand, medium grained at some levels.
2	Ghotaru-I 12.5 Kms Ghotaru to Longewala	1999-2000	13500 by compressor	10800 (6506)	151	43	Tubewell	Medium to coarse sand and gravel
3	Ghotaru – II 14.5 Kms Ghotaru to Longewala	1999-2000	Not Developed	–	151	–	–	Fine grained sand –sandstone chips-fine grained S.St.-Kankar .
4	Ghotaru – III 10 Kms from Ghotaru to Longewala. RHS of road	1999-2000	2250 by compressor	7200 (4337)	151	48	Tubewell	Fine grained sand –very coarse grained gravelly sand
5	Ghotaru – IV 3 Kms from Ghotaru to Longewala. RHS of road	1999-2000	32400 by pump	5900 (3554)	151	45	Tubewell	Medium to fine and coarse grained sands
6	Ghotaru – V 150 m NE of Fort	1999-2000	33750 by pump test	2550 (1536)	148	33	Tubewell	Coarse gravelly sands, fine to medium grained sands and occasional clayey sands
7	Ghotaru –VI 1.5 Kms from Ghotaru to Asutar, RHS of road	2000-2001	22500 by pump test	1550 (934)	125	46	Tubewell	Dominantly medium to coarse sands, fine grained and clayey sands at few levels.
8	Dharmi Khu. 3 Kms from Kishengarh to Dharmi Khu, RHS of road	2000-2001	35100 by pump test	1700 (1024)	153	40	Tubewell	Fine and medium grained sands
9	Ranau – I*	1998-1999	9120 by compressor	1676 (1010)	102	42	Tubewell	Fine grained sand and silt with kankar; fine to medium sand
10	Ranau – II*	1998-99	18240 by	1660 (1000)	120	58	Peizometer	
11	Karthai*	1998-1999	12312 by compressor	2990 (1800)	125	42	Peizometer	Mostly Fine sand
12	Nathura Kau* 4.5 Km from Tanot, 250 m RHS of road	1999-2000	12768 by compressor	4410 (2656)	120	36	Peizometer	Fine grained sand and silt with kankar
13	Kuria Beri*	1998-1999	12768 by compressor	2150 (1295)	131	32	Tubewell	Mostly fine sand
14	Ghantiyali I* 500 m from Ghantiyali Mandir to Tanot, LHS of road	1998-1999	11400 by compressor	3650 (2200)	130	62	Peizometer	Fine grained sand, Out of channel

Note: Yield by pumps are normally higher than the compressor yield by factor of 1.5 to 2.0

* Wells are drilled by the CGWB

resembling a corn-cob feature. Formation of Corn-Cob structures has been reported by the Dr Farouk El-Baz of the Center of Remote Sensing, Boston University[19], in the western Saudi Arabian desert between Hijaz mountains and the Kuwait. The corncob structures formed due to resistance of advancing sand dunes by existing water bodies (rivers/ lakes etc.) could be delineated along the palaeo channels in Karthai-Kuriaberi-Dost Mohammed sections, and along south and south east of Dost Mohd. over a large area (Fig. 1). Based on the mechanism of formation of Corn Cob structures/dune pattern, it could be inferred that these patterns were formed along with the other dominant dune patterns in the area.

Table II

Results of age analyses of samples collected from Jaisalmer study area

ID No.	Location	Well type	rwl# (m) (m)	Depth* (m)	EC** (mS/cm)	d^2H (‰)	$d^{18}O$ (‰)	$^3H\pm0.5$ (TR)	$d^{13}C$ (‰)	$^{14}C+(1s)$ (pMC)	Age (BP) (a), UC	Model Age, a (Pearson)
D1	Dharmikhu	DW	63.2	50	2330 (1390)	-	-7.5	2.1	-9.6	79.5 (2.2)	1900	M
D2	Kishangarh	DW	61.8	35	4180 (2500)	-40.9	-	1.1	-	91.9 (1.7)	-	-
T1	Kishangarh	TW	-	-	3460 (2070)	-41.7	-5.6	0.3	-5.7	47.3 (1.4)	6190	M
D3	Kuriaberi	DW	56.3	39	2100 (1260)	-42.6	-5.7	0.5	-8.3	58.8 (1.6)	4390	134
D4	Nathurakua	DW	62.3	35	3040 (1820)	-38.4	-6.3	0.3	-7.9	69.3 (1.8)	3000	M
D5	Ghantiyali	DW	57.9	38	2820 (1690)	-41.2	-6.0	0.6	-	54.9 (1.5)	4960	-
T2	Ghantiyali	TW	-	-	3660 (2190)	-45.6	-6.6	0.5	-4.0	31.2 (1.2)	9630	550
D6	Khariakua	DW	63.8	-	8900 (6320)	-	-4.8	-	-	-	-	-
D7	Gajesingh ka tar	DW	64.1	40	4620 (2770)	-	-4.7	2.1	-7.7	64.9 (1.9)	3570	M
D8	Ranau	DW	54.8	55	2060 (1230)	-46.1	-6.0	1.7	-	-	-	-
T3	Ranau	TW	-	62 (74-147)	1890 (1130)	-45.3	-6.2	0.6	-7.4	48.8 (1.5)	5930	1930
D9	Sadewala	DW	52.8	45	9120 (5460)	-43.6	-6.3	0.8	-13.6	-	-	-
T4	Sadewala	TW	-	35 (87-161)	7600 (4550)	-	-3.4	0.4	-7.7	06.6 (0.9)	22450	18800
D10	Loungewala	DW	51.6	45	9370 (5610)	-39.9	-5.9	1.0	-	-	-	-
T5	Loungewala	TW	-	-	2740 (1640)	-44.0	-6.2	0.4	-5.6	10.4 (0.9)	18700	12400
T6	Gumnewala	TW	-	65 (87-147)	4060 (2430)	-30.0	-6.1	0.6	-	-	-	-
D12	Ghotaru	DW	39.7	42	3650 (2180)	-41.1	-6.4	1.1	-	62.7 (1.9)	3860	-
T7	Ghotaru	TW	-	40 (91-157)	2270 (1360)	-48.7	-6.9	0.4	-7.3	20.7 (1.0)	13000	8910
D13	Asutar	DW	37.4	65	2390 (1430)	-	-	0.3	-	-	-	-
T8	Asutar	TW	-	68 (73-95)	2560 (1530)	-47.0	-6.3	0.4	-7.5	36.1 (1.3)	8420	4540
D14	Langtala	DW	39.0	23	2380 (1420)	-46.1	-6.0	1.0	-	64.8 (1.7)	3120	M
H14	Longtala	HP	-	-	3400 (2030)	-39.6	-5.0	0.3	-6.2	68.6 (2.0)	-	-
T9	Shahgarh	TW	-	-	10090 (6040)	-38.0	-6.0	0.4	-	-	-	-
D16	Ratnewala	DW	-	28.3	10330 (6180)	-	-4.7	-	-	-	-	-
D17	Dostmohamed kua	DW	-	47.2	1380 (820)	-	-6.5	1.0	-7.6	49.7 (1.5)	5780	2000
D18	Mituwala	DW	-	71.7	6780 (4060)	-	-4.6	0.6	-11.0	57.9 (1.7)	4520	3800
D19	Kolutala	DW	-	-	-	-	-5.8	0.3	-	-	-	-

rwl : Reduced water level TR : Tritium ratio pMC : Percent Modern Carbon M : Modern UC : Uncorrected ‰ : per thousand

** *TDS figures are given in the bracket (meq/l)*

* Depth to water level, depth of screens in the tube well are given in the brackets

Source : Data is provided by Ground Water Department (GWD), Government of Rajasthan, Jodhpur & also taken from ref.[20]. Isotopic and age analysis is carried out by the BARC, Mumbai for the samples collected by the GWD.

Evidences Regarding Existence of Palaeo-Channels

Water Quality

Analysis of water samples collected from the wells along the palaeo channels in the western part of Jaisalmer district indicate that the Palaeochannels form a source of good quality ground water (EC < 2000 micro mhos/ cm/ 29°C and TDS~1500 meq/l.). The thickness of palaeochannels in this area is ~15 – 40 meters. The salinity of water away from the palaeochannels rises sharply. A well at Ghantiyali, in immediate vicinity of palaeochannel on the outer edge had a TDS ~2500 meq/l.. The existing open well at Tanot (near temple), which is about 1.5 km away from the channel has TDS 6337 meq/l. and EC ~9260 μm/ cm/29°C.

Fluvial Sediments in the Drill Core

The presence of a gravel zone and medium to coarse-grained sand at (40 – 125 m) in the litho-logs has been taken as the prime indicator of the Palaeochannels. Gravel and medium to coarse sand was encountered in five of the bore wells (Nos. 2, 4, 5, 6 and 7 in Table I) and fine to medium sand in another four bore wells (Nos. 1, 3, 8 and 9 in Table I) drilled during first phase of the project (Table I). Water levels in most of the borewells drilled ranged from 35-40 meters. And are now being monitored at Ghantiyali and Kuriaberi by peizometers.

Chemical analysis of water samples from these wells showed EC around 2000 micro-mhos/ cm at 29° C as compared to the water quality encountered in the region away from the palaeochannels (EC ~8000 – 12,000 micro-mhos) (Fig. 4).

Age

Radiocarbon dating of waters and the use of Pearson model indicate ages as follows : Kuriaberi 1340a BP, Ghantiyali 550a BP, Ranau TW 1930a BP, Sadewala 18800a BP, Longewala 12400a BP, Ghotaru 8910a BP, Dost Mohd. 2000a BP (Source: Ground Water Department, GOR, Jodhpur[20]), (Table-II). These wells are located either on the palaeo Channel or very close to it, hence age analysis of water samples from palaeochannels also indicate a palaeo source[21].

Conclusion

Digital merging of high resolution PAN and medium resolution LISS_III data brought out subtle features of palaeochannels and helped delineation of further narrower anomalies within the broad palaeochannels (corncob anomalies) for ground exploration.

Exploration of palaeochannels carried out through drilling methods in the Jaisalmer district and the analysis of the data generated under the project specially data on water quality, sediment type and age of groundwater confirmed presence of palaeochannels in the Jaisalmer district as a source of acceptable quality drinking water.

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