

Seismic velocity anisotropy of sheeted dike at the Oman Ophiolite complex

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Abstract

Anisotropy within oceanic layer 2 was found by marine seismic survey. It is explained by dike orientation and fault orientation. We confirmed this anisotropy by shallow seismic survey at the sheeted dike complex of Oman Ophiolite. We could observe an significant anisotropy along dike orientation within oceanic layer 2C (sheeted dike complex).

Introduction

Anisotropy within oceanic layer 2 were found by refraction survey. Otherwise, anisotropy within rock sample was not significant about sheeted dikes.

Some paper reported about oceanic layer 2 anisotropy from borehole data (Stephen 1981, 1985, Little and Stephen, 1985 etc.). Preferred crack orientation or linear block faulting were note as cause of anisotropy. Probably, borehole data, two ship data and OBS data show the such effect, but they cannot get the velocity data which pass only the target layer, layer 2.

If we deploy the all source and receiver on same sheeted dike block, we can get the layer 2 velocity data without perturbation. Our objective of this experiment is to detect an anisotropy within oceanic layer 2C (sheeted dike complex) which may be caused by a dike orientation or other structure.

Experiment

In December 1995, we carried out a shallow seismic survey at the sheeted dike

complex of Oman Ophiolite. Oman Ophiolite is reported as an abducted oceanic plate which was made at a fast spreading ridge in Mesozoic. This Ophiolite complex forms 10-15km thick nape. The block size of the sheeted dike complex which was cut by fault and valley is about 100 m.

Study sites were outcrops of sheeted dike along the Wadi Bani Umar and outcrops of sheeted dike near the Wadi Fizeh (Fig. 1 and Fig. 2). We carried out the two perpendicular survey lines at each site (Fig.3 Fig. 4 and Fig. 5). The length of survey lines were about 100 m. We used 10 sensors (Mark Products L-28, 4.5Hz, U-D). Sensor interval was about 10 meters.

Result

In both site, we observed a significant anisotropy (Fig. 6). Data from sensors located near source show lower velocity. They show the weathered layer velocity because their path is shallow. Distant sensors data show faster and steady velocity. We use these data as representative velocity of each line. In preliminary results, low velocity values are about 3.6km/s. High velocity values are about 4.2 - 4.5km/s. Low velocity was observed in the perpendicular direction of the sheeted dike plane. High velocity was observed in the parallel direction of sheeted dike.

Discussion

These results are qualitative result about anisotropy caused by dike structure and

cracks. Velocity ratio may be amplified in 1 ATM condition because of small crack opening and weathering of dike plane. But same effects are expected in oceanic Layer 2B. As a future problem, velocity measurement in laboratory of sheeted dike plane is important. If we will measure some sheeted dikes block velocity under the in situ pressure, We can separate the effect of crack and effect of weak dike plane (closed crack).

References

Stephen, R. A., Seismic anisotropy observed in upper oceanic crust , G. R. L., Vol 8, pp865-868, 1981

Stephen, R. A., Seismic anisotropy in the

upper oceanic crust , J. G. R., Vol 90, pp11,383-11,396, 1985

Little S. A. and R. A. Stephen, Costa Rica rift borehole seismic experiment, Deep Sea Drilling Project Hole 504B, Leg 92 , J. G. R., Vol 90, pp11,383-11,396, 1985

Crampin, S. Geological and industrial implications of extensive-dilatancy anisotropy, Nature Vol. 328, pp491-pp496

Wilkins, R. H. and M. H. Salisbury, Microstructure and physical properties of samples from hole 896A, Proc. ODP Sci. Results, Vol. 148, 365-374, 1996

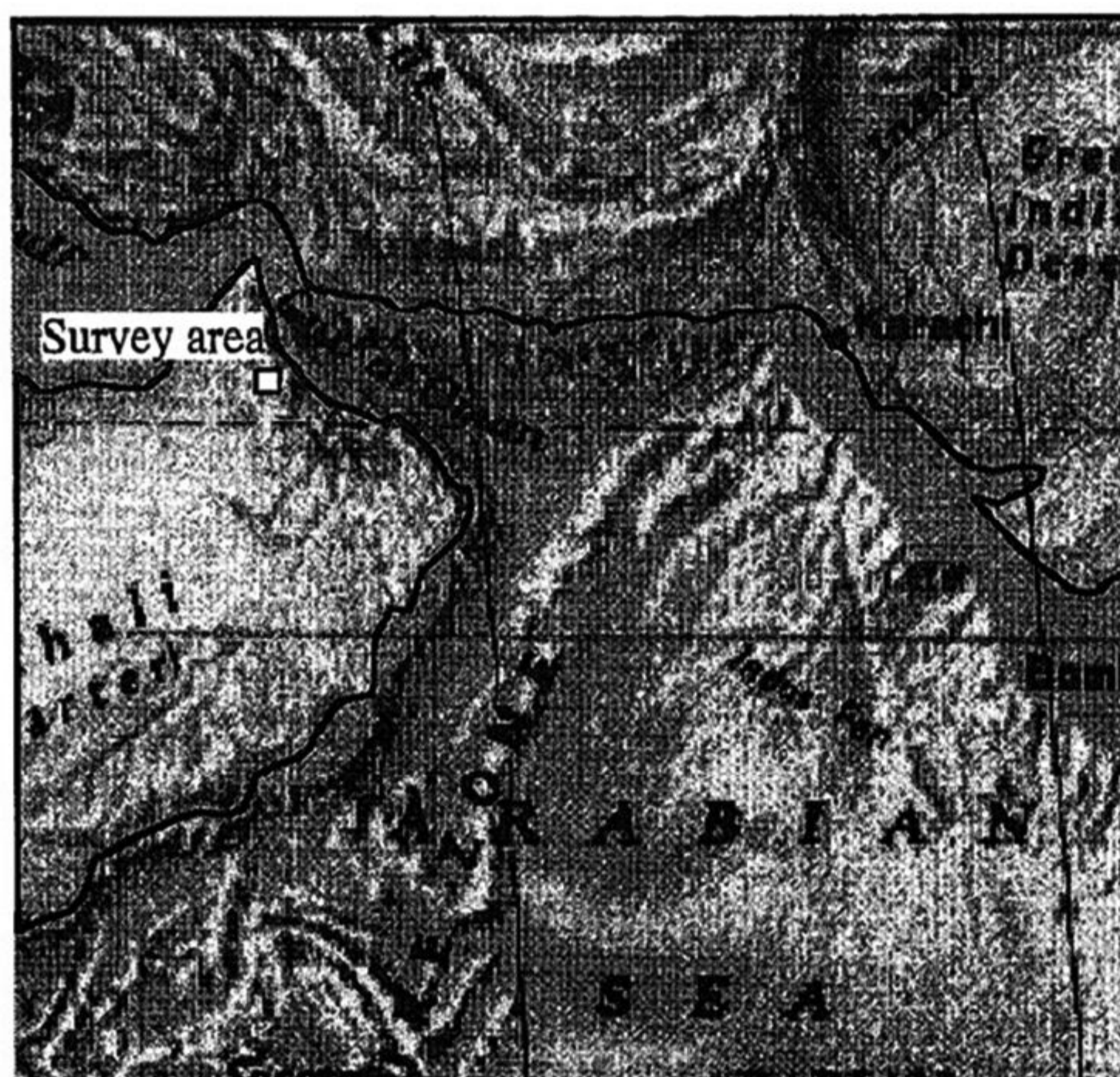


fig. 1 Location ma

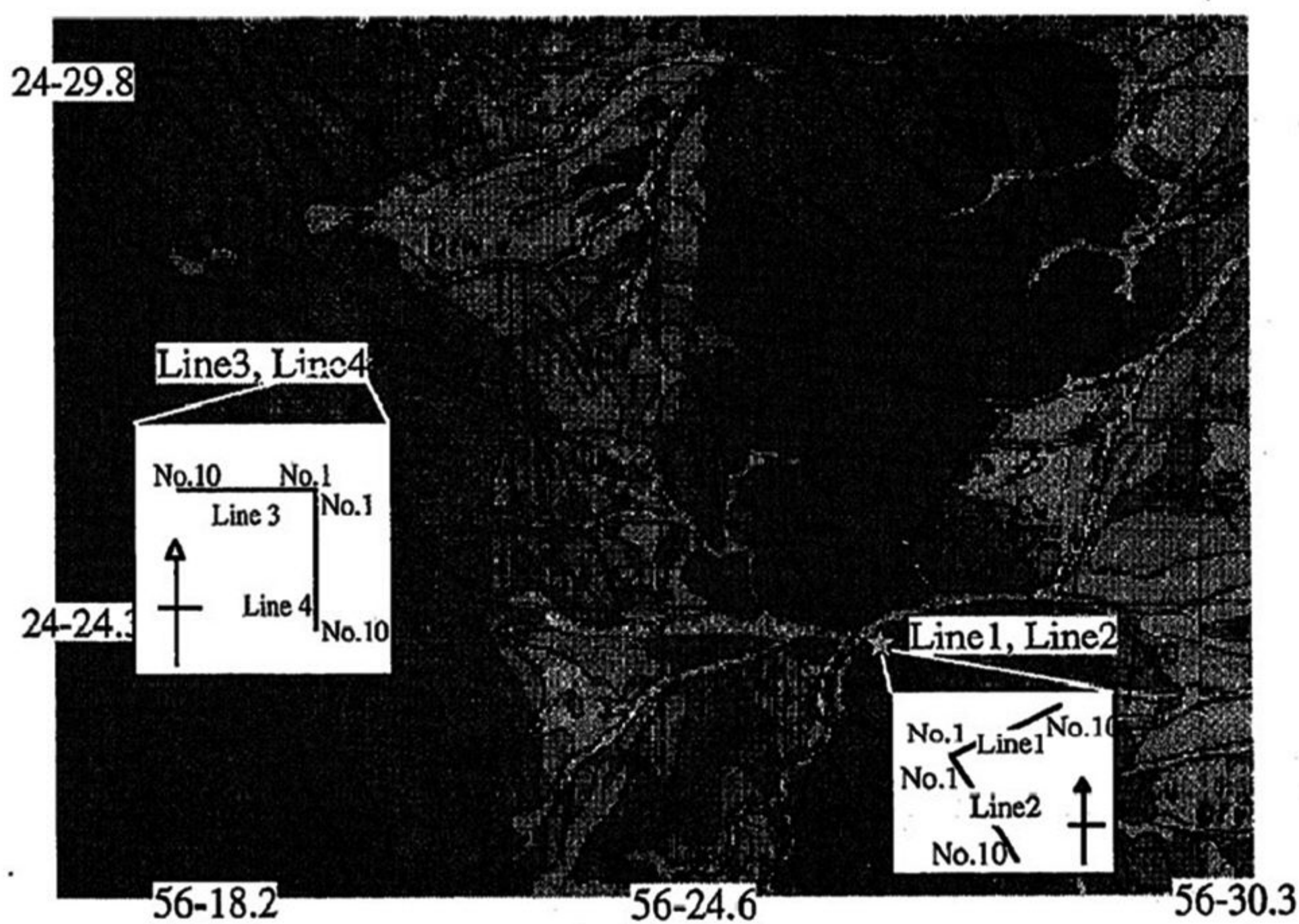


fig. 2 Study area

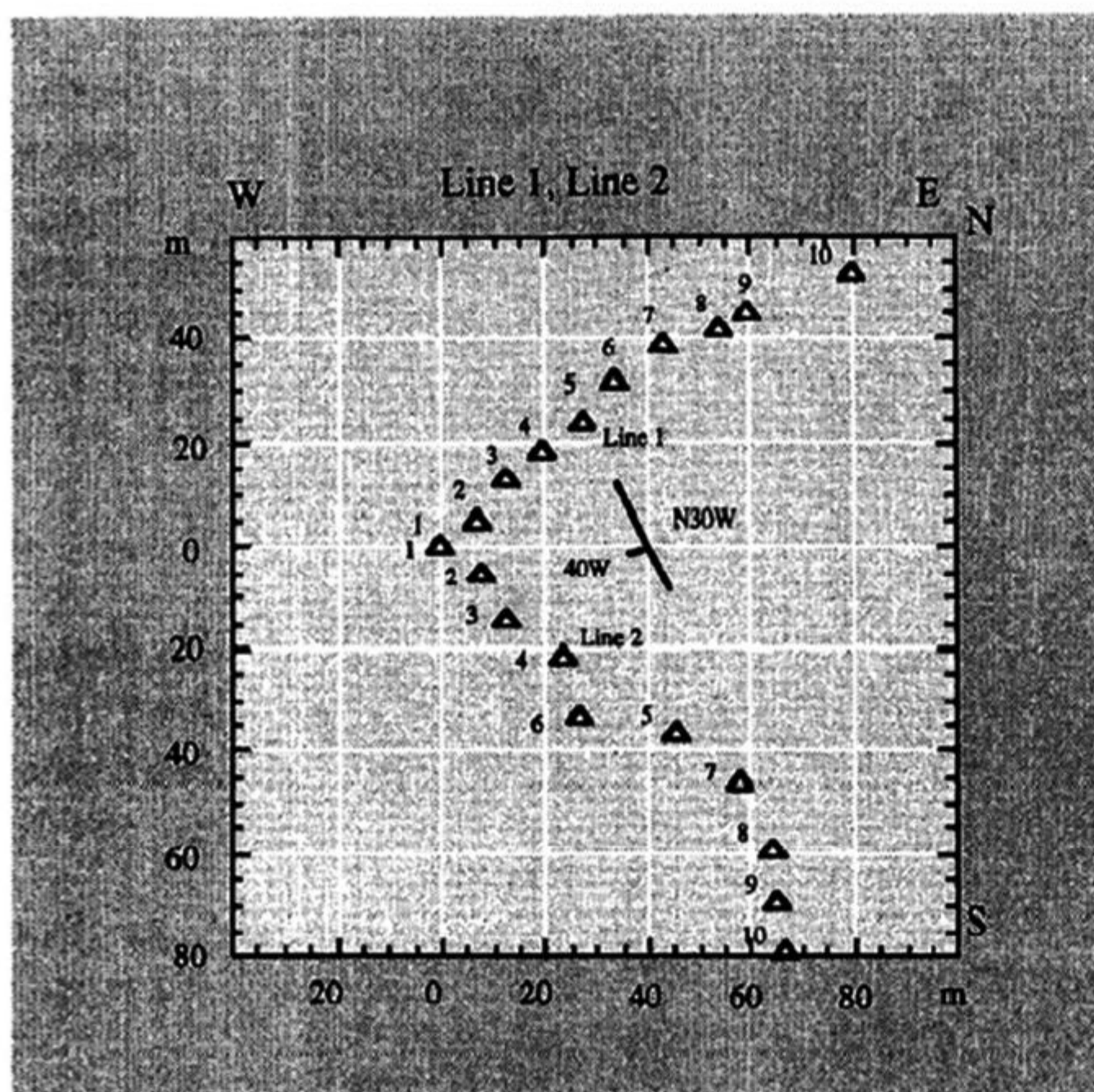


fig. 3 Sensor lay out of line 1 and line2

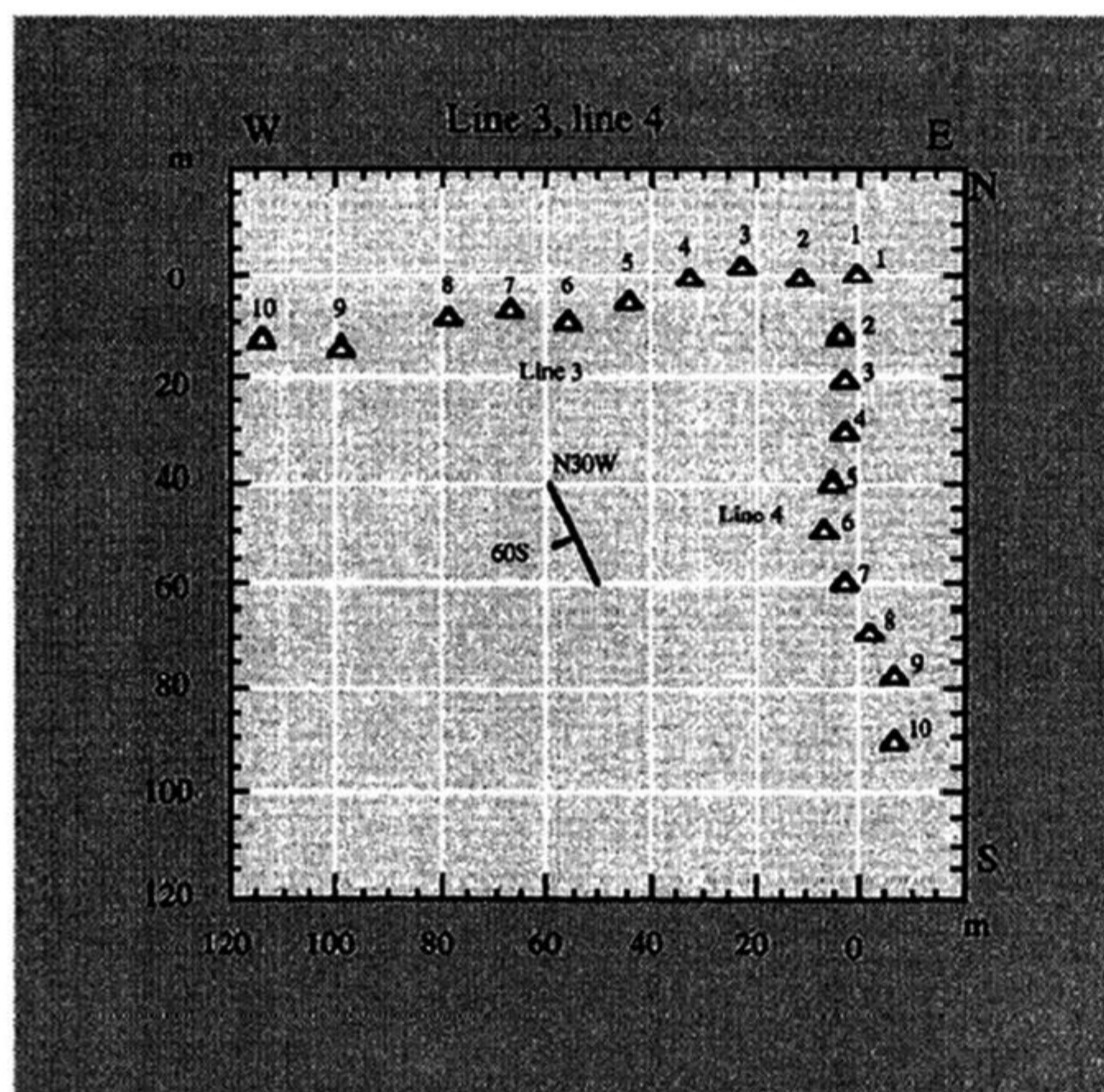


fig. 4 Sensor lay out of line 3 and line4

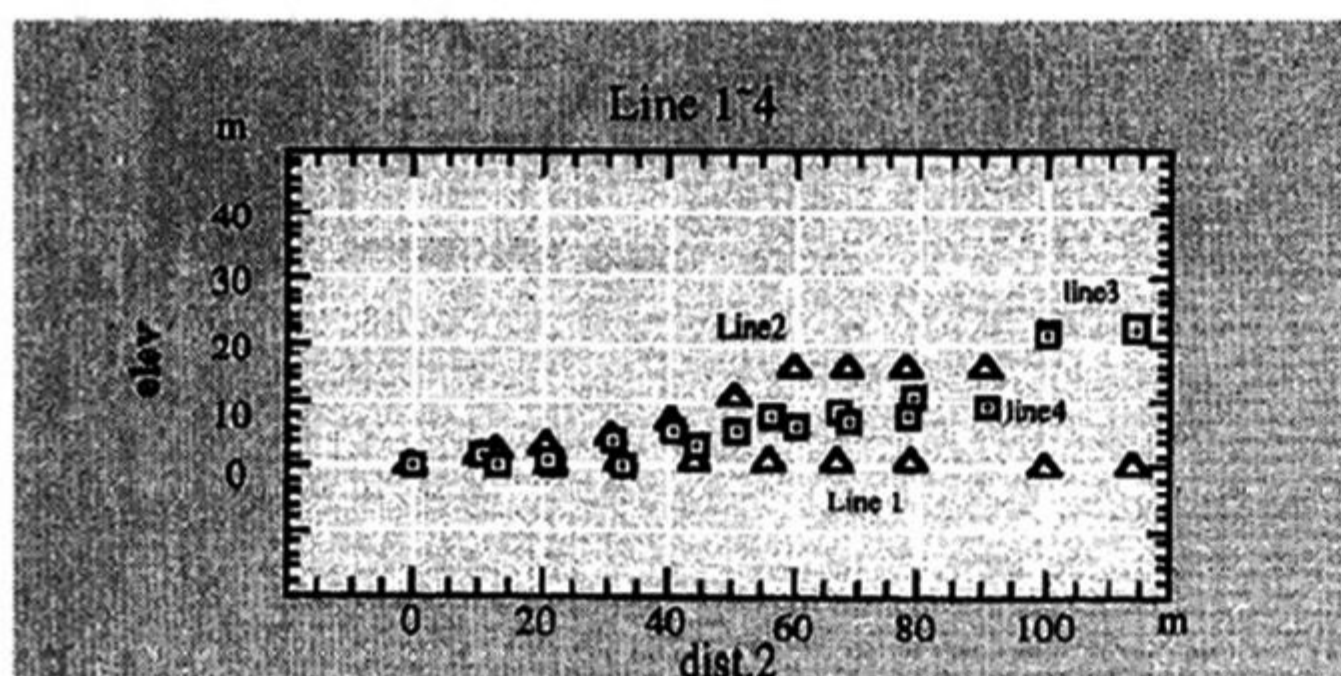


fig. 5 Elevation of each Sensor

Line1	shot	2	3	4	5	6	7	8	9	10	
distance from shot Pt.	m	0	9.09173	18.0218	26.5181	36.409	46.6509	58.1276	67.9289	74.5662	96.3432
Travel Time	sec	0	6.1	9	12.5	14.4	15.9	18.7	22.1	23.7	25.8
velocity	km/s		1.5	2	2.1	2.5	2.9	3.1	3.1	3.1	3.7

Line1	1	2	3	4	5	6	7	8	9	shot	
distance from shot Pt.	m	96.3432	87.389	78.7863	70.3547	60.5367	51.0577	39.6774	29.0514	22.3477	0
Travel Time	sec	26.2	24.6	21.4		16.4	13.8	12.6	10.7	9	0
velocity	km/s	3.7	3.6	3.7		3.7	3.7	3.1	2.7	2.5	

Line2	shot	2	3	4	5	6	7	8	9	10	
distance from shot Pt.	m	0	9.64498	19.8961	32.3778	43.6336	59.0707	75.922	88.623	96.6357	104.645
Travel Time	sec	0	6.8	10.8	14	16.4	14.6	18.6	20.1	22.4	24.6
velocity	km/s		1.4	1.8	2.3	2.7	4	4.1	4.4	4.3	4.3

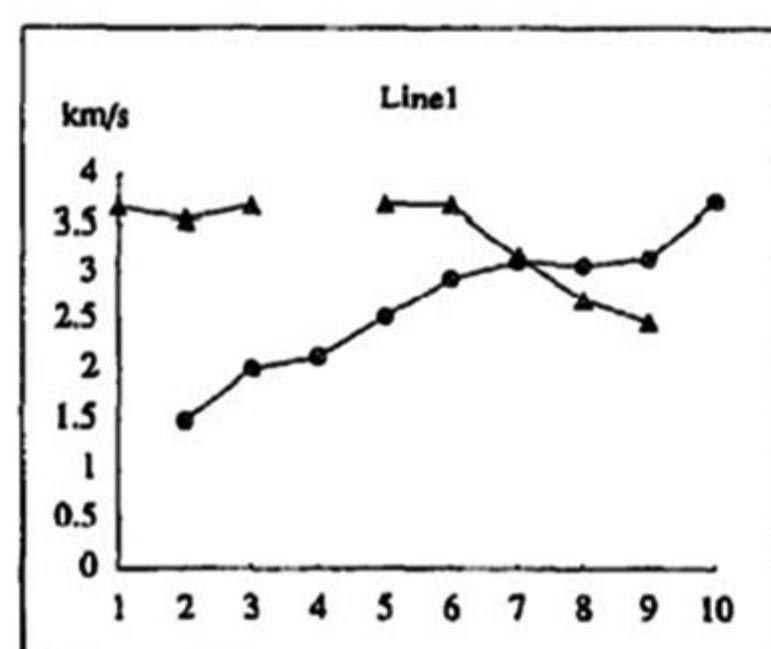
Line2	1	2	3	4	5	6	7	8	9	shot	
distance from shot Pt.	m	104.645	94.9996	84.7485	72.2667	61.011	45.5738	28.7225	16.0216	8.00881	0
Travel Time	sec	24.4	22.6	20.6	18.6	16.2	17.4	14.9	7.7	4.2	0
velocity	km/s	4.3	4.2	4.1	3.9	3.8	2.6	1.9	2.1	1.9	

Line3	shot	2	3	4	5	6	7	8	9	10	
distance from shot Pt.	m	0	10.7674	21.9274	32.4019	44.3041	56.8079	67.7929	79.9634	102.079	116.582
Travel Time	sec	0	6.1	11	13.2	16.4	17.4	19.4	23.3	28.9	33.3
velocity	km/s		1.8	2	2.5	2.7	3.3	3.5	3.4	3.5	3.5

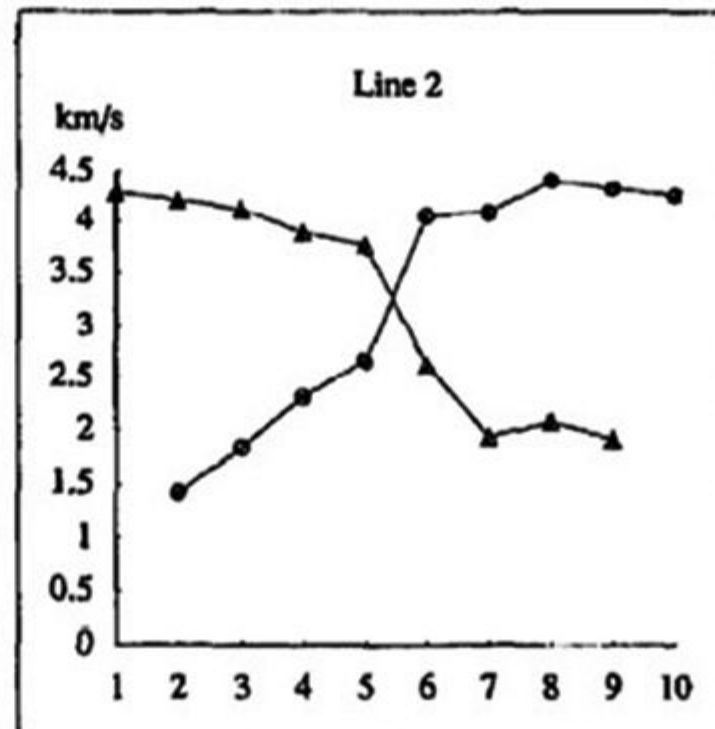
Line3	1	2	3	4	5	6	7	8	9	shot	
distance from shot Pt.	m	116.582	105.815	94.6549	84.1804	72.2782	59.7744	48.7894	36.6189	14.5037	0
Travel Time	sec	32.1	28	24	21.3	21.2	20.1	16	13	4.4	0
velocity	km/s	3.6	3.8	3.9	4	3.4	3	3	2.8	3.3	

Line4	shot	2	3	4	5	6	7	8	9	10	
distance from shot Pt.	m	0	12.7506	21.0838	31.0608	40.8678	50.746	60.5338	69.4751	78.3687	91.0757
Travel Time	sec	0	3.4	4.8	7.2	8.7	10.7	12.8	14.2	16.7	20.1
velocity	km/s		3.8	4.4	4.3	4.7	4.7	4.7	4.9	4.7	4.5

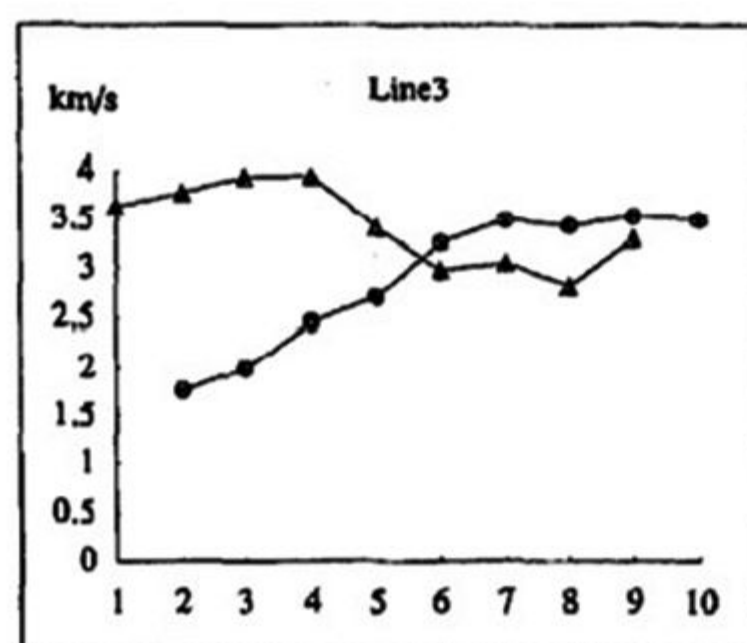
Line4	1	2	3	4	5	6	7	8	9	shot	
distance from shot Pt.	m	91.0757	78.3251	69.9919	60.0149	50.2079	40.3297	30.5419	21.6006	12.707	0
Travel Time	sec	21.3	18.8	16.9	13.8	11.4	9.3	7.3	5.3	3.4	0
velocity	km/s	4.3	4.2	4.1	4.3	4.4	4.3	4.2	4.1	3.7	



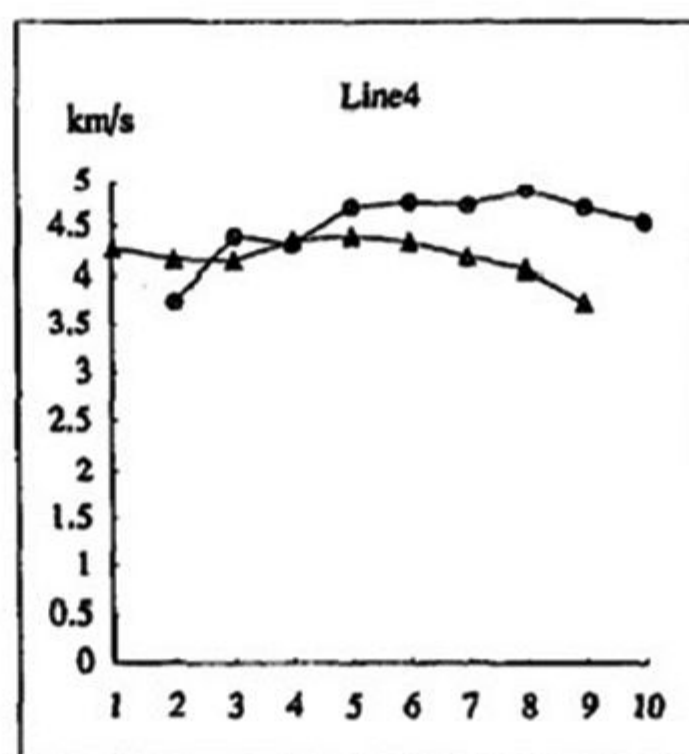
Line1 : Perpendicular to Dike



Line2 : Parallel to Dike



Line3 : Perpendicular to Dike



Line4 : Parallel to Dike

fig. 6 Observed apparent velocity at each line