

A19

Goodbye Noise, Hello Signal! Improving Microseismic Monitoring in Noisy Environments

F.H. Kindy* (PDO), G. Engen (PDO), I. Ismaily (PDO), N. Touqi (PDO) & A. Yahyai (PDO)

SUMMARY

Over the last decade, Petroleum Development of Oman have deployed several microseismic monitoring systems. Due to the maturity of many of the oilfields in Oman, anthropogenic noise is in abundance. Given that the magnitude of some of the microseismic events can be as low as M = -3, noise can seriously hamper the detection and/or processing of such events. This paper describes PDO's experiments on new hardware and software to increase S/N. We show some examples of how our implementation techniques improved event detection thresholds. In addition, we propose simple solutions that are not only more effective at noise reduction, but are also cheaper both in implementation and in reducing the subsequent cost of data processing.



Over the last decade, Petroleum Development of Oman have deployed several microseismic monitoring systems, These mainly consist of permanent downhole geophones cemented in dedicated observation wells to help monitor processes such as water and steam injection or caprock integrity.

However, due to the maturity of many of the oilfields in Oman, anthropogenic noise is in abundance. Sources of such noise include surface noise (trucks, construction etc.), electrical noise from cables, logging, cathodic protection (Figure 1 and 2) and production noise from injectors and producers. Given that the magnitude of some of the microseismic events can be as low as M = -3, noise can seriously hamper the detection and/or processing of such events.

1	1	2	3	4	5		6	7	8	1	9	10		11	12	1:		14	15		Clust	ering file n	ame :						
				F:V	(Transit\c	bo\3P\b	eau3P	N							4	p20102	02_004	1958.sg2					•	2		1	Sho	w Header	
J.	Filter1		[-10,85	i,3]	1 🗖	Filter2		[+]	0,45,3]												De	scaling				0		- V	V/cc
T I	Sun 2	0-0 ct-2002		00.48	58				An	in = -7,	Amax	= 8; (Ch:	an QA	25_1H2	273								Sam	pling tate	: 2000 sp	35		(Gain
5_1H1X			i				÷	www								······						i					~~~~		{}
	ານເລຍ ແຂວນາຍ	una lutra fu	maxing	in the base	AWAANA	NORMAN OF	ineer	au shi	COLUMNIA	andus	iuuus	monte	MARE	MARK	usiana	NADUA	autoniu	UNITARI	niaaaaa	and the second	<u>uusannee</u>	aninana	ninisiuuun	antinia	DUM DÉD	a an	NUCLEUR	ເຫັກສະຫຼັກແຜ	шİ
	mast com	02201280		antatuia	AVUGABLE	Margineters	in the second	200000	Dening the	in the	COLUMN ST	ulahia.	1.000	DHAR	utintel	1420014	hubbbl	NUMBER OF	000000	Unititititi	Walanda	00.80600	Internation of the	nutue	Willing	MARGINAL	MARQUAR	UNHUB TU	iii
	0009003000	លកុលភ្លោព	minakut	holublic	2UMabu	MARAUNI	utobi	an in the second second	den de la com	ផ្សំណេច	BUILLE	interprise	QUAN	nuur	uusauu	MARINA	hulmber	POUL NOT	00662033	United	ULUMANDE	antisan	nhiautua	authous	ULLANDO	HARLING	NUMBER	in the base of the	1
	un suttanin	MIRCH INCOM	0100010	annun a	UULGAID	HARLUN	-	ALL WE AND	address of the	WIND	in the second	intertere	W.Links	IDMAS.	uumteh	HARDIN	autowa	RELEASE	004001	Company	NUMBER	antionic	NUCCESS	COLUMN IS	CLUMPER	Magulant	NURGENER	dinautinus.	
	maphicante	Marbulante	amainte	anunhia	ownauth	Magnus		autore a	index.	hulkhu	in the second	Interbuck	DUNK	malas	utiontal	NUMBER OF	autour	ALL DATE	nélesti	unitation):	LUNGION!	antiumte	eletratelete	oto si di	unante	deputant	NUCCUM	midigilla	in.
	and Water	the summer	annin a	annama	ALC: NO DE CONTRACTOR		inter	and the lot	an aire	le atrenue	in the second	obtained	D.U.S.	-	unione	MURDER	olanuus			-	ALL CONTRACTOR	autom	and the second se	alaaws	uunuim		Inducation of the	-	-
9H2Y	and the second	uasuusau	aunium	annaan	ousona	MERINA I	iom	make	A.MALWAR	man		DOM: NO	uuma	-	mine	-	anneur	anuman	ainan		ULL MILLOW	animne		ana	uuumia		ALC: UNK		
5_9VZ	AND BLOWING	-	interior and	in the local data	BONNING	HANNER DA	in the second	New York	white the	Scinicity	NICH	minimi	WANTER	-	-	himsen	In succession	www.	-	ALC: NO.	WWWWWWW	www.hilli	-	INTERNAL OF	-	TANK SHILL	CONTRACTOR OF THE	-	
13H1X	Line and the second	Manage Manager	wine in the		STATE OF THE	enwasu.	in had	and a second	AN COLUMN	id.itelate	in the state	within	-	in the second	Station in	A CONTRACTOR OF THE OWNER OF THE	SNINKW	weater		all writers	lais a la secondada	WARANDER		Karimada)	in the second		unard with the lot	and the second se	
13H2Y	mashcanna	ussion	Auging	anterna	awaata	Managara	STREET,	and stic	design of	(distant	istuate	upobio.	CALIFORNIA COLORING	Munici,	MARINE	interior and a loss	augute	STATISTICS.	COLUCI:	Cantatella	in the second	antimete	Matricellula	outouto	ULL NUMBER	List Contractor	united the second	mandanus	
13VZ	SHARWING ST	-			AWHINA	-	ine	No.	and the second	himsel	NUMBER	minimus	WHR	CHIMAN P	William .	-	12500	NORMINI	-	A DOUGH AND	ANNIHAR MARK	WINNIN	NO MARK	HORE BOARD	and the second	Second Second	-	-	-
- 1	1010201020100	1015 DITEN	onesin.	2010010	nnmoiu	HEALDIN	NHOLES .	an market	Reve day	Colonia Colonia	1011018		COLUMN STATE	Nonese .	Intriantic	PRODUCT	Part of the local division of the local divi	2011/2010	uuuuuu Minenee			en mente	PREPARENT IN	0000000			PRESS INTER	opensuit?	
	asa pilisonna	และแมลแ	MENTON	annous	aumana					munac		UTHER		UNKAUL	HANDLO	HILLING	NUMBER	ULI SAMOL	NULLUIS	in mutanicu	uuuuuu	duakonto	NERGER	DUDGHU	HANDLED	dougenot	MURANA	ហោររប់ប្រ	10
17VZ		No. Contraction								1.1.1.	i Haka	tanharian a	il) (in the second s		ALCONTROL OF							Contraction of the local division of the loc			Nonita Harts	and the second second	delet for depting	Providence in the	
	مالى المالى المالى المالى المالى المالى المالى المالى المالى المالي المالي المالي المالي المالي المالي المالي ا																				and the second second		ر. در ان رختین ویک	-	المالونية	-		A DECEMBER OF	
21H1Y			-	-			-									-				-	Condition and								-
	www.	-	min	فديديديار	معامعته	ير مقصعا،		-	للمعذيبين	واستخلته	ببديق	antus	والما والحال		سننخد	التقداد	-					يعارين فأسع	بالاسلاماد	News	سأعربهم	والانتقاد ومرد			
25H1X																					~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~			ware the	and the		~~~~	in the second	
			-																						Junio		******		
5 25VZ									Ababa	AAAA																			
	minuluann	และแมลก	maaduw	Notinida	อนเลอเม	HOULIN	inaa	aunani	រំណើណផ្តែ	intable	iouwi	mana	DISING	Malan	Habitut	NURTH	nania	DUMADL	nianú	iana ana ang ang ang ang ang ang ang ang	Usannous	anisiana	NEQUEER	nondela	DANOLLAN	LAD CHANNEL	NUCLEUR	maaddaaa	ш
29H2Y	AND	CONTRACTOR OF	ANALY COLOR	und intelligent	AND	Home in the	UNIVERSE OF	10000000	NUMBER OF STREET	DISTAND	AND ALL	Contraction of the	NSI UNI	WALKING !!	RUDOW.	ANN ALL	NO.	Without Info	ARRING ST	MONTANI	Usaliniotainh	Contraction of	MINIMUM	1000 ALCON	Campion	Mercanovice.	Minister Constant	AND A CONTRACT OF A CONTRACT O	1
5 29VZ	•**• (g) g distant								** * Helding H			HX is	O.L.			•**idfi			CHEOD				• - e gjil			er som det stere	• • • • • • • • • • •	er destil	1
	1		0.5				1			1	.5				2	100		TODINE	2.5		100103-00	3			3.5		- Annes	4	
	,		0.5								14		Amin		509 Am	ax = 3.0	1942		0.0						5.5				.0
9								_																				4.	-

Figure 1: Strong electrical noise in microseismic data hampers processing.

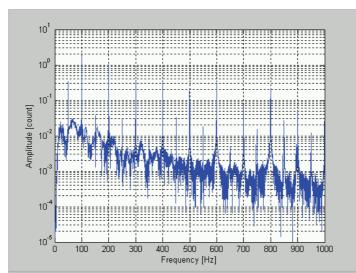


Figure 2: power-spectra of microseismic signal showing strong electrical noise with harmonics.

Due to these issues, PDO have been using as well as experimenting with different 'hardware' and 'software' solutions to reduce / eliminate noise and/or to improve the detected signal quality. These are summarised as follows:



Hardware	Benefits							
Wireless data transfer,	Together, these reduce ambient electrical noise pick-							
Solar power supply,	up and risk of cable damage (signal leakage)							
electrical earthing and								
shielded cables								
Observation well	Cemented geophones give much better coupling with							
locations and design	rock matrix which improves signal amplitude. Using							
	more geophones can also improve event detection							
Improved geophone	By optimising the type and number of phone							
element configuration	elements used per geophone component, the							
and specifications	sensitivity of the system can be increased							
Software	Benefits							
Pre-trigger lag filtering	Done in real time, can considerably reduce number of							
	'false' events in areas of high electrical noise							
Post-trigger filtering and	Many techniques available that can vastly improve							
processing	the number of picked events							

In this paper we show some examples of how techniques such as those in the table above can reduce noise or improve event detection thresholds. In addition, we propose simple solutions that are not only more effective at noise reduction, but are also cheaper both in implementation and in reducing the subsequent cost of data processing.