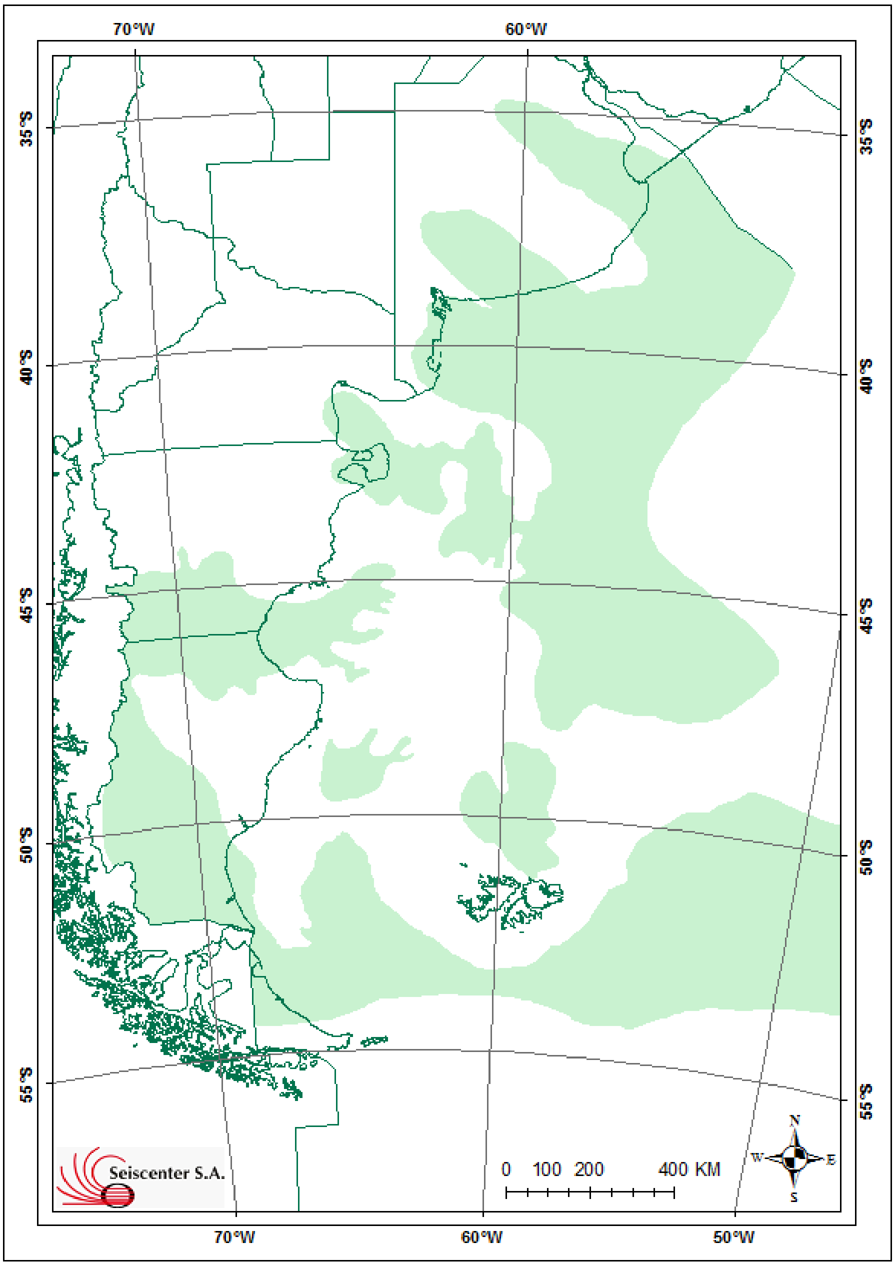
ARGENTINIAN SEA

SEISMIC-WELL DATABASE AND GEOLOGICAL-GEOPHYSICAL REPORT



2020

Contents

I. INTRODUCTION

Seiscenter -www.seiscenter.com.ar-, a Buenos Aires based company providing geophysical services to the oil industry, with more than 20 years in the market and subsidiaries in South America, is pleased to offer its Argentine Sea seismic-geophysical database, which includes well data and a detailed geological-geophysical report.

It follows the first round of oil and gas leases on the Argentinian Sea which was held in 2019, meanwhile a second round is expected in the course of 2020. The Argentinian government trusts that better information will grant a successful leasing process, taking in account that almost 20pc of the Argentinian oil & gas resources come from its offshore basins (see Fig. J, Argentinian offshore basins).

Seiscenter believes its data collection is unparalleled in the market. Beyond the 3Ds (11200 km^2 are made available out of a total of 14100 km^2), we have compiled more than 3100 2D lines and almost 500 wells classified by their outcomes (65% of them with logs and additional data). See Fig. H (2D lines by basin), Fig. M (3D cubes) and Fig. N (well locations)

The fundamental reason supporting this result and its uniqueness is that we have not limited ourselves to the already available official government data. Not only our data include the official version -extensively improved upon- but we have resorted to:

- Files of oil companies currently operating in Argentina
- Files of companies no longer operating in the country
- Private consultants who have preserved information not otherwise available
- Other geophysical services companies
- Interviews with geophysicists and surveyors who worked on the original surveys
- Our own files which are the outcome of several projects developed during ten years for different offshore basins

From all these sources we obtained an impressive amount of data, including stacks in SEG-Y, invaluable base maps, more than 1800 images from old films/hard copies, bathymetry, observer reports and well data. None of this is available in the country's official database.

Upon further examination we found that an important portion of the official data has too many pitfalls to be reliable, mainly in its coordinates, then in its quality and finally in the way they were sorted, standardized and named. It should be noted that older SEG-Y data come chiefly from rasterized films/hard copies, where the SP numbering and coordinates were frequently omitted or were directly wrong. We verified many inconsistencies by checking the official data in SEG-Y against the original images, base maps and bathymetries.

In front of this large set of data, we discussed and decided our policy towards the database, we thought the best value was to focus on improving -both in metadata and imaging through post-stack processing- the older information, nominally acquired and processed on the interval 1965-1995, plus all other data on which we detected inconsistencies. If an inconsistency was checked, its entire survey was verified. Modern information, with more reliable coordinates, better processing and quality, was checked in general and its SEG-Y coordinates and headers were standardized. 3Ds, which by our policy are recent, were compiled, its accessibility verified and in some cases clarified, but the seismic data and original coordinates remain unaffected.

The whole work was driven by the geological framework and keeping in mind a robust interpretation, poor quality lines were dismissed when better ones or 3Ds were available and their data overlapped, special attempts were devoted to improve or recover lines deemed to be of strategic relevance.

This project is accompanied and supported by an exclusive and up-to-date description of the geological-geophysical context, petroleum systems, reservoirs, source rocks, traps, seals, main fault trends and known plays. It is a special insight regarding the Argentinian Offshore of more of 140 pages of detailed information, basin by basin. Exploration history, well results, recommendations and remaining potential. See Fig. O (table of contents) and Fig. P (excerpts)

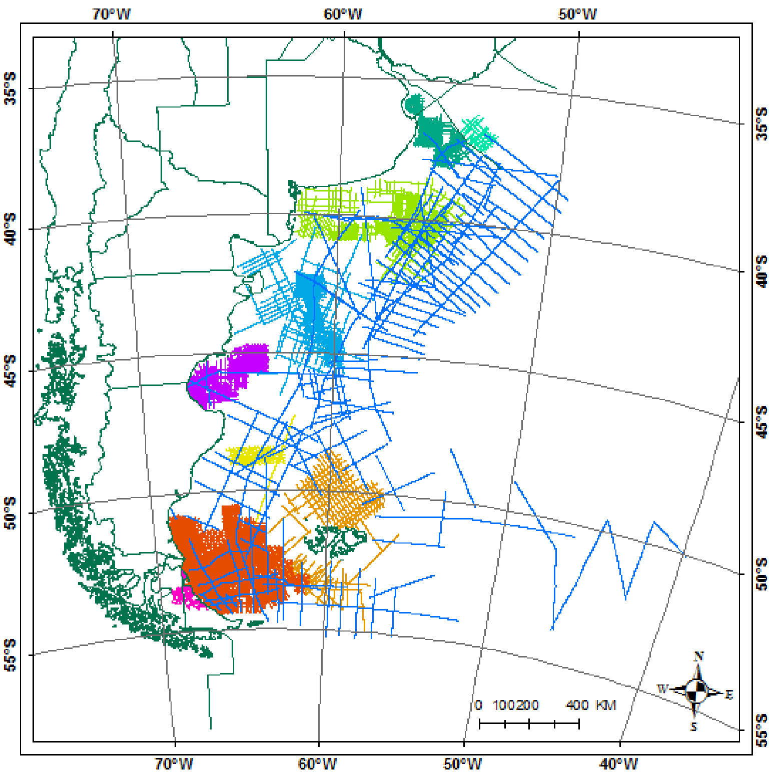
This was an important effort, we are satisfied to offer its results and to know that they can contribute, by quantity and quality, to a better study and development of the energy resources of the Argentine Sea.

II. 2D SEISMIC

The project was carried out on a total of 3121 2D lines, more than 19.5 million traces, amounting to 224727 km which distribute per basin:

	BASIN	LINES	KM
	REGIONAL-ARGENTINA	156	43.298
	AUSTRAL ONSHORE	90	2.359
	AUSTRAL-MALVINAS	1644	82.840
	MALVINAS NORTE-SUR	59	12.065
	SAN JULIAN	79	5.325
	GOLFO SAN JORGE	363	18.649
	RAWSON-VALDES	191	20.990
	COLORADO	309	24.733
	SALADO	215	12.915
	PUNTA DEL ESTE	15	1.553
	TOTAL	3121	224.727

Table A 2D lines and kilometers per basin



Seismic lines distribution map. Color code follows Table A

i. Input Data

1. Seismic Information

The input seismic information, a compendium of many decades of seismic acquisition, was varied in terms of types and quality, from poor quality (Fig. A) to high quality (Fig. B). The whole project was curated in such a way that very poor quality lines, poor quality lines overlapping newer, better versions, and lines with explicit wrong/doubtful coordinates were excluded.

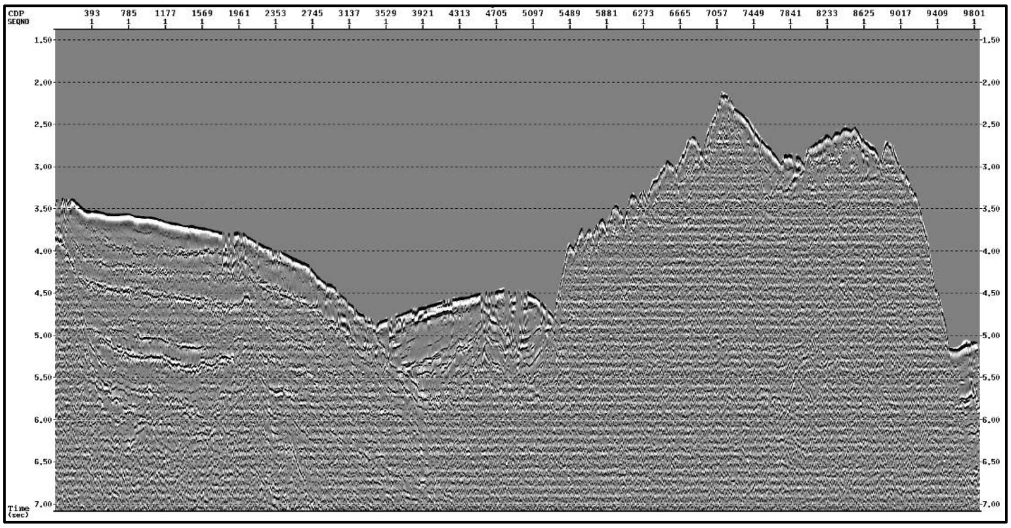


Fig. A poor quality 2D line. From a remastered SEG-Y, not removed timelines hinder the background information. Seiscenter did its best to recover this kind of lines trough processing or vectorization when the original images were available in our Image Database (see pg. 8)

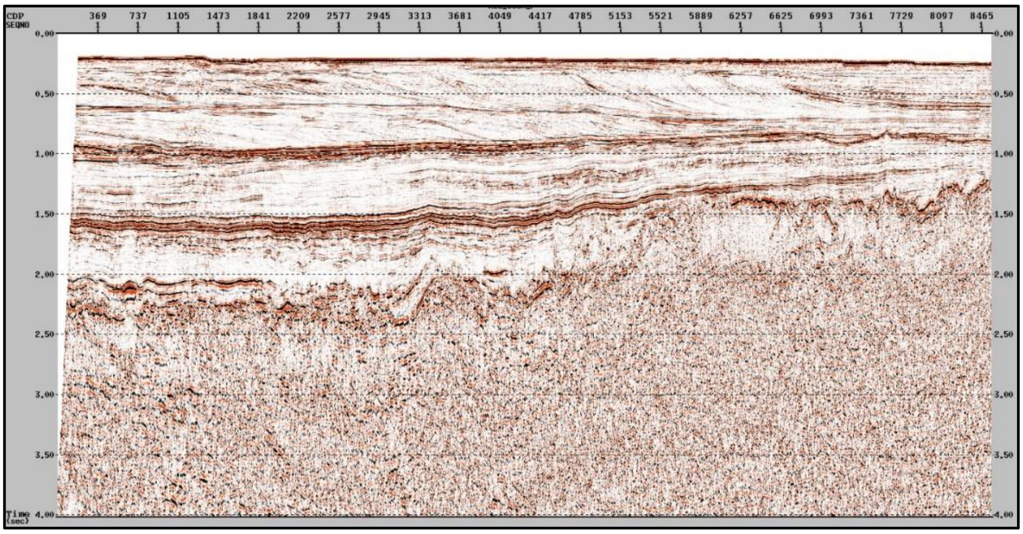


Fig. B High quality 2D line. Recent acquisition and processing

The following table attempts to systematize data types by some differentiation criteria, being each set of input data a combination of the different described criteria.

CRITERION	TYPE
DATA SOURCE	SEG-Y FROM PROCESSING
	SEG-Y FROM SCAN
	IMAGE FROM SCAN
DATA INTEGRITY	COMPLETE LINE
	SPLIT LINE
ACQUISITION	OFFSHORE
	ONSHORE
VERTICAL SAMPLE INTERVAL	2 MS
	4 MS
TRACE DECIMATION	WHOLE SET OF TRACES
	DECIMATED TRACES
PROCESS TYPE	STACK
	POST-STACK MIGRATION
	PRE-STACK MIGRATION

Table B, List of criteria which helped to classify the seismic information

On the other hand, it is also possible to sort the seismic information by basins and acquisition surveys. While this kind of grouping does not guarantee homogeneity in the sense of Table B, it is useful to associate the year of the survey, its parameters and expected quality.

2. Coordinates

This has been a critical point, there was not for the project a single, reliable and unified base or reference to be used. There are two strong sources of uncertainty:

A. Related to the acquisition epoch:

1. From 1995 to the present, the most accurate data as it comes directly from modern positioning equipment available on board.
2. 1980 – 1995, is an intermediate period, where several surveys were acquired with somewhat outdated technology and others began to incorporate acceptable navigation systems.
3. 1965 - 1980, is the most erratic period for geodesic information. In general, isolated coordinates were settled through satellite positioning devices from which planimetries were generated following course and speed of the ship. Unfortunately, we must add errors involved in the digitizing process of the

original planimetry on paper and often such digitization is the only remaining source of coordinates

B. Related to the availability and quality of the information:

1. Navigation files in different formats, accuracy and projections
2. Digitizations, planimetries and shapefiles from diverse sources with little or no specification
3. Coordinates in SEG-Y headers with little or no specification about their geodesic system, projection and source

All this information from different backgrounds in terms of acquisition method, year, geodesic system, projection, accuracy, et cetera; is often non-consistent, incomplete or poorly specified, making it not reliable enough to be used without carrying out validations and intensive data crosschecking.

3. Shortcomings on remastered SEG-Ys and Seiscenter's Image Database from Films/Paper copies and Observer Reports

Seiscenter has made available to the project its database of more than 1800 rasterized images and 1400 observer reports. These images come from original observer reports and film/hard copies, standard outcomes from older processing sequences. Some films/hard copies have been lost/damaged themselves since then and the same has happened to the field data. These images and the occasional SEG-Y remastered files -with its shortcomings- are then the last remaining information for many surveys.

Checking the Image Database (Fig. D) has proved to be a resourceful way to address several problems:

A- Vectorization

A sizeable proportion of the available information comes through SEG-Y files from a rasterization / vectorization process of films or hard copies.

Some common shortcomings are:

1. Poor quality of the original film or paper copy (stained, worn out)
2. Deformations during the rasterization process (the film slides not uniformly)
3. Deformations during the imaging vectorization process (corners are not identified properly, resulting in a wrong number of traces)
4. Trace decimation during the imaging vectorization process
5. A very frequent faulty assignation of coordinates and/or SP or CDP numbers to SEG-Y headers

In this sense checking Seiscenter's Image Database can easily address points 3 to 5, otherwise much of the information would be dismissed or would remain with errors.

B- Migration

Many stacks were non-migrated ones, Seiscenter has tried to bring on migrated versions wherever possible. Migration needs an approximate velocity field, Seiscenter's Image Database is an irreplaceable source of velocity data provided that local velocities were posted on films or hard copies. In no way velocity data can be retrieved from digital SEG-Y formats.

C- Georeferencing / Merging

The Image Database was also used to resolve coordinate inconsistencies, to check stations intervals, shot numbering and crossing locations. Likewise, it helped the process of splicing arbitrary splits for many lines.

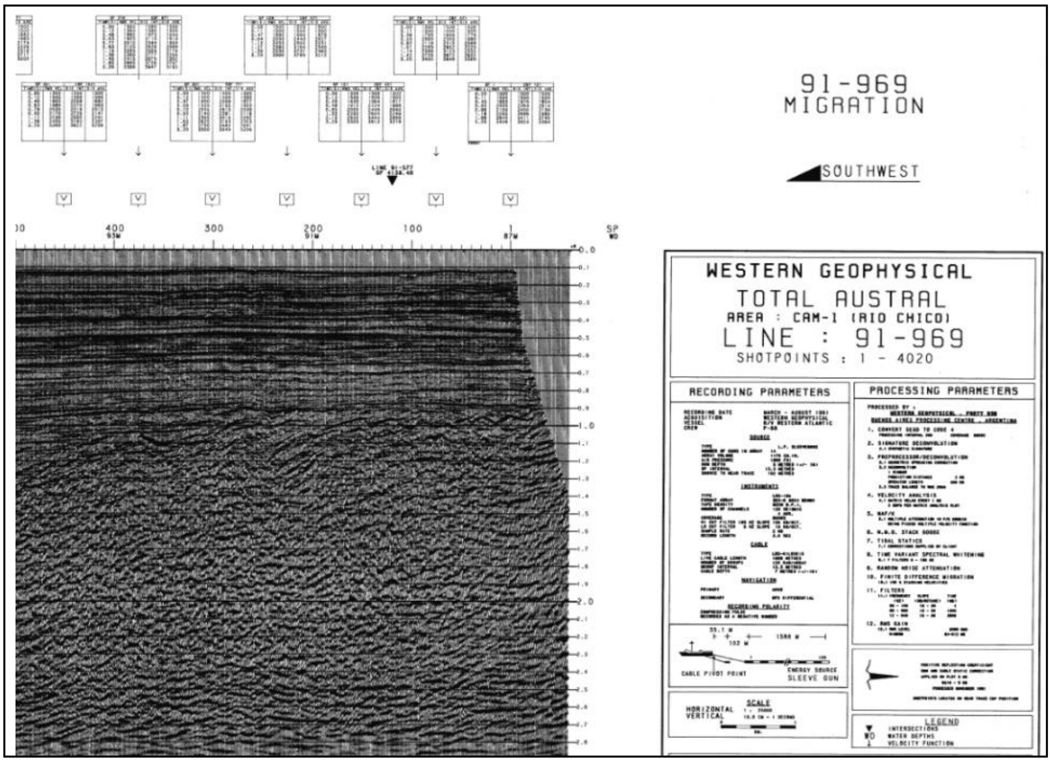


Fig. C Seiscsenter's Image Database, more than 1800 images with toplabel stacking velocities and sidelabel acquisition parameters

ii. Processing Sequence (post-stack)

#	Task
1	Classification
2	Merges
3	Multiple attenuation
4	Post Stack Deconvolution
5	Interpolation (H)
6	Interpolation (V)
7	Band Pass Filtering
8	FX Filtering
9	Cohere FK Filtering
10	Notch Filtering
11	Post-Stack Migration
12	Band Pass Filtering
13	FX Filtering
14	Spectral Balance
15	Mute
16	Coordinates: assessing and validation
17	SEG-Y Generation
18	Shape File Generation

Table C, processing sequence

This sequence was not applied as a whole, modules were used according to specific requirements and data characteristics.

1. Classification

This early stage allows an appropriate first classification and to assess the application of tasks and modules:

CRITERION	INPUT TYPE	%	ASSOCIATED TASK #
DATA SOURCE	SEG-Y FROM PROCESSING	60%	
	SEG-Y FROM SCAN	38%	NOTCH (10)
	IMAGE FROM SCAN	2%	NOTCH (10)
DATA INTEGRITY	COMPLETE	54%	
	SPLIT LINE	46%	MERGE (2)
ADQUISITION	OFFSHORE	99%	MULTIPLE REMOVAL (3)
	ONSHORE	1%	
VERTICAL SAMPLE INTERVAL	2 MS	1%	
	4 MS	99%	INTERPOLATION V (6)
TRACE DECIMATION	WHOLE SET OF TRACES	42%	
	DECIMATED TRACES	58%	INTERPOLATION H (5)
PROCESS TYPE	STACK	44%	MIGRATION (11)
	POST-STACK MIGRATION	45%	
	PRE-STACK MIGRATION	11%	

Table D, classification by criteria, input type and associated tasks

On the other hand, a sort by survey (Table F) allowed us to make a general classification by quality (Table E) and foresee a specific sequence for each survey.

QUALITY	LINES	KM	%
BAD	59	15468	7%
REGULAR	1122	73420	33%
MEDIUM	1324	72396	32%
GOOD	454	36721	16%
HIGH	162	26721	12%
TOTAL	**3121**	**224727**	**100%**

Table E, classification by quality

BASIN	SURVEY	LINES	KM	INTER. SP	DIG. DATA	STATUS	QUALITY
REGIONAL-ARGENTINA	WG	24	8119	MIX	SCAN	STK	BAD
REGIONAL-ARGENTINA	GSI	12	3303	50	SCAN	STK	BAD
REGIONAL-ARGENTINA	WARG92	23	5409	27	SCAN-TIFF	MIG	REGULAR
REGIONAL-ARGENTINA	BGR87	4	1387	50	SCAN-TIFF	STK	MEDIUM
REGIONAL-ARGENTINA	YMN-1995	11	1352	25	PROC	STK	MEDIUM
REGIONAL-ARGENTINA	BGR98	38	6929	50	PROC	MIG	GOOD
REGIONAL-ARGENTINA	SPAN-2008	21	10763	13	PROC	MIG	HIGH
REGIONAL-ARGENTINA	COPLA	23	6036	50	PROC	MIG	HIGH
AUSTRAL ONSHORE	TIERRA DEL FUEGO	61	1467	MIX	PROC-SCAN	STK-MIG	MEDIUM
AUSTRAL ONSHORE	CHILE	29	892	MIX	PROC	MIG	MEDIUM
AUSTRAL-MALVINAS	A81A-ESSO-1980	138	4670	15	PROC-SCAN	STK-MIG	REGULAR
AUSTRAL-MALVINAS	GSI-78	23	4047	50	SCAN	STK	BAD
AUSTRAL-MALVINAS	80-1980	67	3242	25	SCAN	STK	REGULAR
AUSTRAL-MALVINAS	A80A-ESSO-1980	81	3001	25	PROC-SCAN	STK-MIG	REGULAR
AUSTRAL-MALVINAS	82-1-1982	59	1669	13	SCAN	STK	REGULAR
AUSTRAL-MALVINAS	GSI-79	17	1079	50	SCAN	STK	REGULAR
AUSTRAL-MALVINAS	SHELL-1982	39	731	MIX	SCAN	STK	REGULAR
AUSTRAL-MALVINAS	80-1-1980	20	488	25	SCAN	STK	REGULAR
AUSTRAL-MALVINAS	MULTIPLE	9	519	MIX	PROC-SCAN	STK	REGULAR
AUSTRAL-MALVINAS	WESTERN-1991	233	13106	13	PROC-SCAN	MIG	MEDIUM
AUSTRAL-MALVINAS	MV-1990	98	6854	MIX	PROC-SCAN	MIG	MEDIUM
AUSTRAL-MALVINAS	SHELL-1979	150	8315	13	PROC-SCAN	STK-MIG	MEDIUM
AUSTRAL-MALVINAS	79-1-1979	144	4629	MIX	PROC-SCAN	STK-MIG	MEDIUM
AUSTRAL-MALVINAS	WESTERN-1992	62	3568	13	PROC-SCAN	MIG	MEDIUM
AUSTRAL-MALVINAS	84-1-1984	169	2459	13	SCAN	STK	MEDIUM
AUSTRAL-MALVINAS	86-1-1986	13	210	13	SCAN	STK	MEDIUM
AUSTRAL-MALVINAS	91-1-1991	11	293	13	PROC-SCAN	STK-MIG	MEDIUM
AUSTRAL-MALVINAS	84-2-1984	11	117	13	SCAN	STK	MEDIUM
AUSTRAL-MALVINAS	91-2-1991	1	18	13	PROC-SCAN	STK-MIG	MEDIUM
AUSTRAL-MALVINAS	YCM-1998	111	10589	25	PROC	MIG	GOOD
AUSTRAL-MALVINAS	CAA35-1993	48	3239	27	PROC	MIG	GOOD
AUSTRAL-MALVINAS	SWAT-1997	31	3118	25	PROC	MIG	GOOD
AUSTRAL-MALVINAS	CAA35-1994	38	2156	25	PROC	MIG	GOOD
AUSTRAL-MALVINAS	CAA35-1998	42	1767	25	PROC	MIG	GOOD
AUSTRAL-MALVINAS	86-2-1986	2	31	13	PROC-SCAN	STK	GOOD
AUSTRAL-MALVINAS	SP38-1998	27	2926	25	PROC	MIG	HIGH
MALVINAS NORTE-SUR	FALK	31	7340	25	PROC	MIG	REGULAR
MALVINAS NORTE-SUR	GFI-93	28	4725	40	PROC	MIG	MEDIUM
SAN JULIAN	1991-BRA	75	4608	27	SCAN	MIG	REGULAR
SAN JULIAN	MULTIPLE	4	717	MIX	SCAN	STK	REGULAR
GOLFO SAN JORGE	MULTIPLE	131	5192	MIX	PROC-SCAN	STK-MIG	REGULAR
GOLFO SAN JORGE	D	52	2743	70	SCAN	STK	REGULAR
GOLFO SAN JORGE	NS	28	1423	MIX	SCAN	STK	REGULAR
GOLFO SAN JORGE	EW	20	1307	MIX	SCAN	STK	REGULAR
GOLFO SAN JORGE	80-1980	132	7984	25	PROC	STK-MIG	MEDIUM
RAWSON-VALDES	MULTIPLE	58	9534	MIX	SCAN-TIFF	STK	REGULAR
RAWSON-VALDES	AR9A	40	1067	25	SCAN	MIG	REGULAR
RAWSON-VALDES	AR7A	93	10390	22	SCAN	STK-MIG	MEDIUM
COLORADO	MULTIPLE	111	11540	MIX	PROC-SCAN	STK	REGULAR
COLORADO	91	24	1361	25	PROC-SCAN	STK	REGULAR
COLORADO	96	34	2445	25	PROC-SCAN	STK	MEDIUM
COLORADO	SHC95C-1995	48	3140	25	PROC	MIG	GOOD
COLORADO	95	16	805	25	PROC	STK	GOOD
COLORADO	YCC-1999	48	3659	25	PROC	MIG	HIGH
COLORADO	YCC-2002	28	1783	25	PROC	MIG	HIGH
SALADO	MULTIPLE	73	4402	MIX	PROC-SCAN	STK-MIG	REGULAR
SALADO	GS	22	1379	180	PROC	STK	REGULAR
SALADO	IBK2-1991	40	2186	25	PROC	STK-MIG	MEDIUM
SALADO	93	36	2826	25	PROC	STK	GOOD
SALADO	YCS-1995	44	2122	25	PROC	MIG	GOOD
PUNTA DEL ESTE	URUGUAY	15	1553	25	PROC	MIG	HIGH
TOTAL		3121	224727				

Table F, classification by quality, basin and survey

2. Merge

A significant number of lines were split and given arbitrary names and SP/CDP numbering, probably as a legacy of many leasing reconfigurations; although, they were acquired and processed as a whole. We found from two up to six splits which give unnecessary complications to the interpretation, data loading and assessment tasks.

Wherever possible they were restored to their original status. Again, the Image Database came in particularly handy on this step.

3. Water-bottom multiple attenuation

Seiscenter has developed an algorithm for a quick attenuation of water-bottom related multiples which was applied whenever it was deemed necessary.

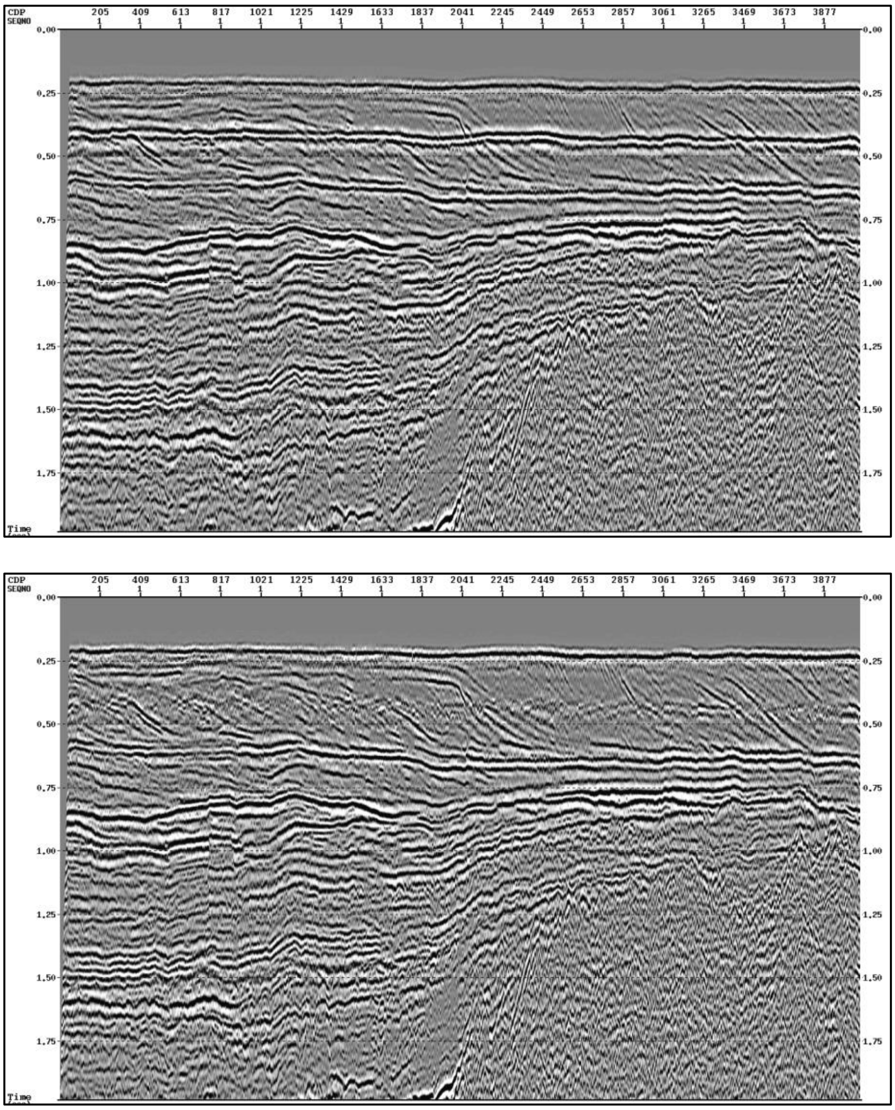


Fig. D Austral Basin, 1974, before (above) and after (below) multiple attenuation

4. Deconvolution

Deconvolution has here the purpose of overriding undesirable effects of some previous filtering and to flat the spectrum response, easing the recognition and resolution of events. It has been a useful step applied to older data and remastered SEG-Ys.

5. Horizontal Interpolation

Mild or strong trace decimation during the processing or imaging vectorization were a common place due to hardware limitations. After checking against the Image Database, the planned traces ratio was restored. This process has several advantages, allows a more intuitive assessment and data interpretation, reflects actual SP numbering and helps the migration process avoiding possible spatial aliasing.

6. FK filtering

Many FK spectrums showed spatial aliasing and related noises which were treated by a dedicated FK filtering (Fig. E).

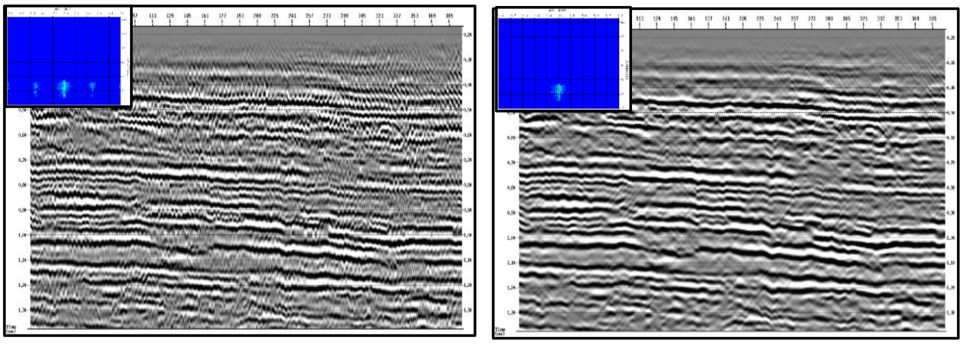


Fig. E before (left) and after (right) FK filtering

7. Timelines attenuation

SEG-Y input data after the vectorization of images frequently has values associated to residual timelines mixed up with seismic events (Fig. A). Frequency Hi-Fi Notch filters were designed to address this problem or, if the original images were available, they were vectorized again and the timelines removed during the process.

8. Post-stack Migration

Unmigrated seismic sections were migrated (Fig. F) using local stacking velocities and parameters taken from the Seiscenter's Image Database (Fig. C).

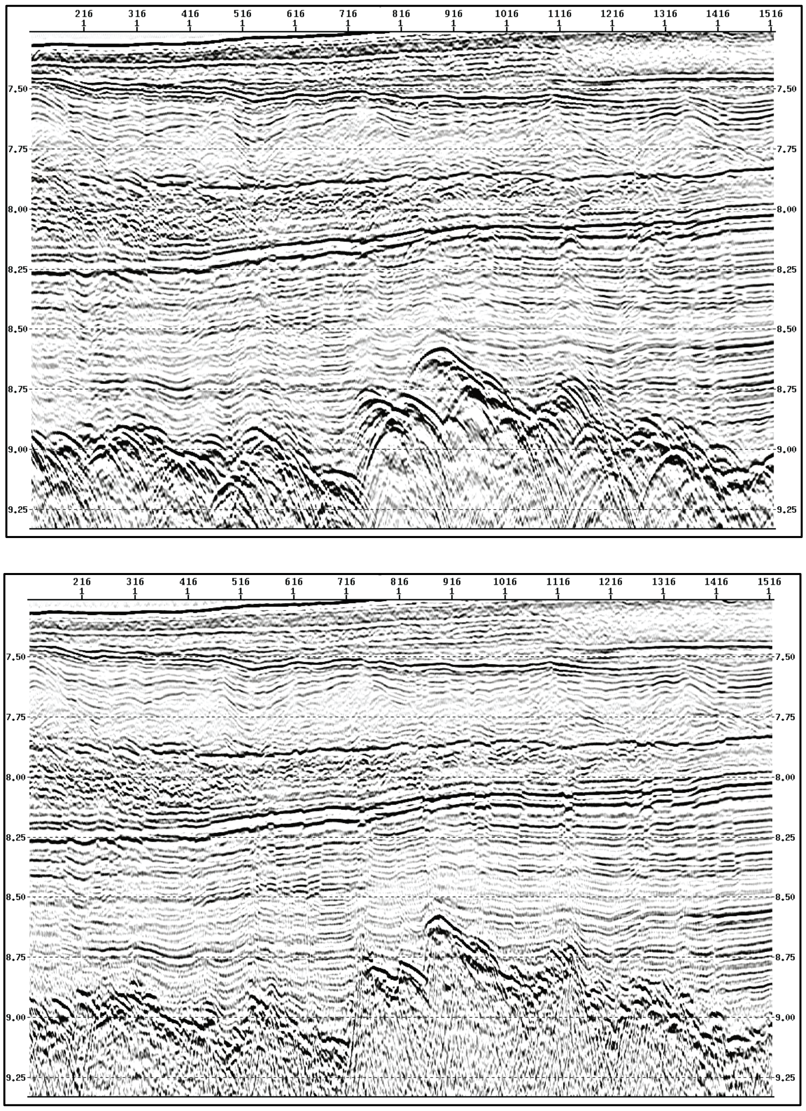


Fig. F Colorado Basin, 1973, before (above) and after (below) migration

9. Final filtering – Spectral Balance – Mute

Finally, a general homogenization was performed by applying frequency filters, spectral balance and mute, as per a survey basis, especially on older surveys rendered by vectorized SEG-Ys.

10. Coordinates: calculation and validation

Beyond inaccuracies, coordinates description on SEG-Y headers (EBCDIC and traces) were very poor, non-standardized or absent. We devoted much effort to validate and calculate appropriate coordinates.

SEG-Y Trace Headers (common to the whole project)

BYTES: 17-20 SP	(INTEGER)
BYTES: 21-24 CDP = M X SP	(INTEGER)
BYTES: 73-76 LATITUDE	(IBM FLOAT)
BYTES: 77-80 LONGITUDE	(IBM FLOAT)

Regional – Argentina, Austral – Malvinas, Malvinas North – South, San Julián, Golfo San Jorge, Rawson – Valdés, Colorado y Salado

BYTES: 81-84 CDP X UTM 21 - WGS84	(IBM FLOAT)
BYTES: 85-88 CDP Y UTM 21 - WGS84	(IBM FLOAT)
BYTES: 181-184 CDP X UTM 20 - WGS84	(IBM FLOAT)
BYTES: 185-188 CDP Y UTM 20 - WGS84	(IBM FLOAT)

Austral Onshore

BYTES: 81-84 CDP X UTM 19 - WGS84	(IBM FLOAT)
BYTES: 85-88 CDP Y UTM 19 - WGS84	(IBM FLOAT)
BYTES: 181-184 CDP X UTM 20 - WGS84	(IBM FLOAT)
BYTES: 185-188 CDP Y UTM 20 - WGS84	(IBM FLOAT)

Punta del Este

BYTES: 81-84 CDP X UTM 21 - WGS84	(IBM FLOAT)
BYTES: 85-88 CDP Y UTM 21 - WGS84	(IBM FLOAT)
BYTES: 181-184 CDP X UTM 22 - WGS84	(IBM FLOAT)
BYTES: 185-188 CDP Y UTM 22 - WGS84	(IBM FLOAT)

The following routine procedures were used to validate coordinate values and avoid significant errors:

1. Controlling lines length and intervals between SP and receivers
2. Verification of the geometry against Seiscenter's Image Database
3. Use of seabed data and bathymetries available as a confirmation of the general positioning
4. Checking seismic events at crossing locations on the same survey

A final checking, using lines from other surveys, preferably those deemed as more reliable than the current one being checked (Fig. G)

Seiscenter S.A.

Seiscenter's experience suggests that the procedure brings a robust approximation according to the available data, with the caveat of those coordinates coming from digitized base maps at small scales.

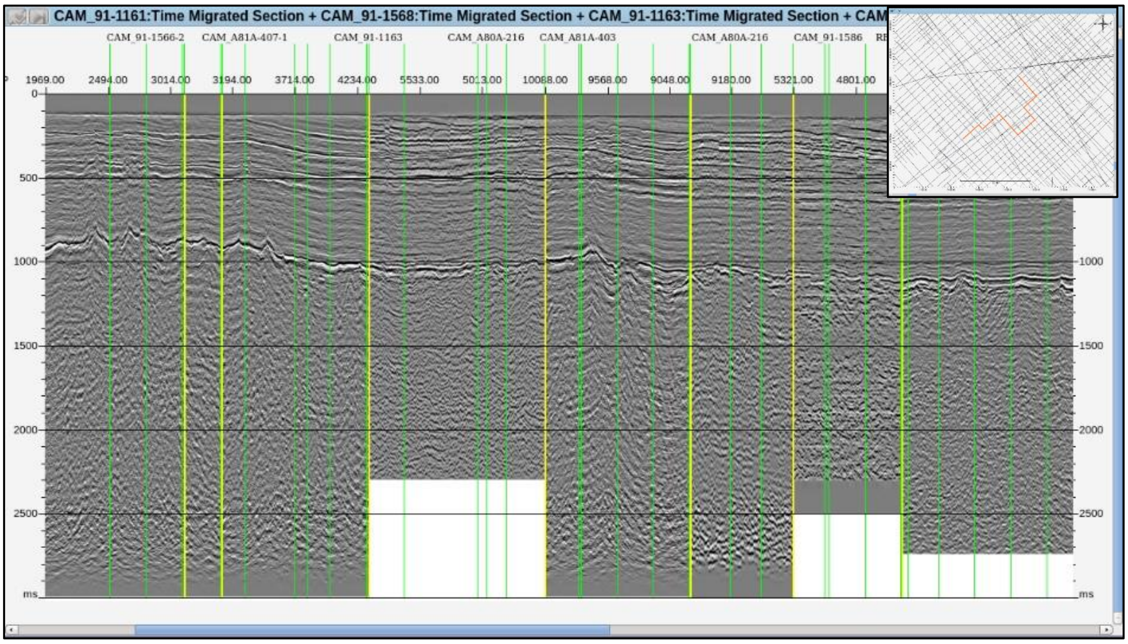


Fig. G Coordinates checking on Austral-Malvinas basin linking different surveys

11. Shapefiles

For each basin shapefiles were generated for all their coordinate systems (Fig. H and Fig. I),

- TOTAL_SP (every 20 SP)
- TOTAL_LINES
- FIRST_LAST_SP
- Regional – REG_ SP (every 20 SP)
- Regional – REG_Lines
- Austral Onshore – CAT_SP (every 20 SP)
- Austral Onshore – CAT_Lines
- Austral-Malvinas – CAM_SP (every 20 SP)
- Austral-Malvinas – CAM_Lines
- Malvinas North-South – CMNS_SP (every 20 SP)
- Malvinas North-South – CMNS_Lines
- San Julián – CSJ_SP (every 20 SP)
- San Julián – CSJ_Lines
- Golfo San Jorge – CGSJM_SP (every 20 SP)
- Golfo San Jorge – CGSJM_Lines
- Rawson-Valdés – CRVM_SP (every 20 SP)

- Rawson-Valdés – CRVM_Lines
- Colorado – CCM_SP (every 20 SP)
- Colorado – CCM_Lines
- Salado – CSM_SP (every 20 SP)
- Salado – CSM_Lines
- Punta del Este – CPDE_SP (every 20 SP)
- Punta del Este – CPDE_Lines
- Country/States boundaries
- Cuenca Argentina – Basin boundaries
- Cuenca Austral – Basin boundaries
- Cuenca Malvinas – Basin boundaries
- Cuenca Malvinas Norte – Basin boundaries
- Cuenca Malvinas Oriental – Basin boundaries
- Cuenca San Julian – Basin boundaries
- Cuenca San Jorge – Basin boundaries
- Cuenca Rawson – Basin boundaries
- Cuenca Península Valdés – Basin boundaries
- Cuenca Colorado – Basin boundaries
- Cuenca Salado – Basin boundaries

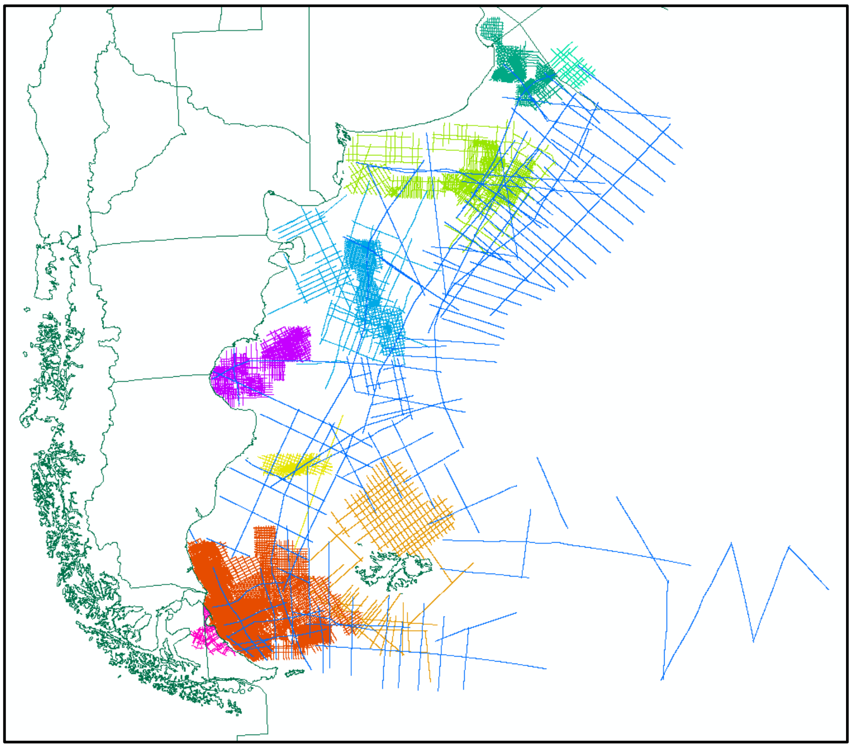


Fig. H Shapefiles map, by basin and regional lines (colors by basin -see Fig. J-)

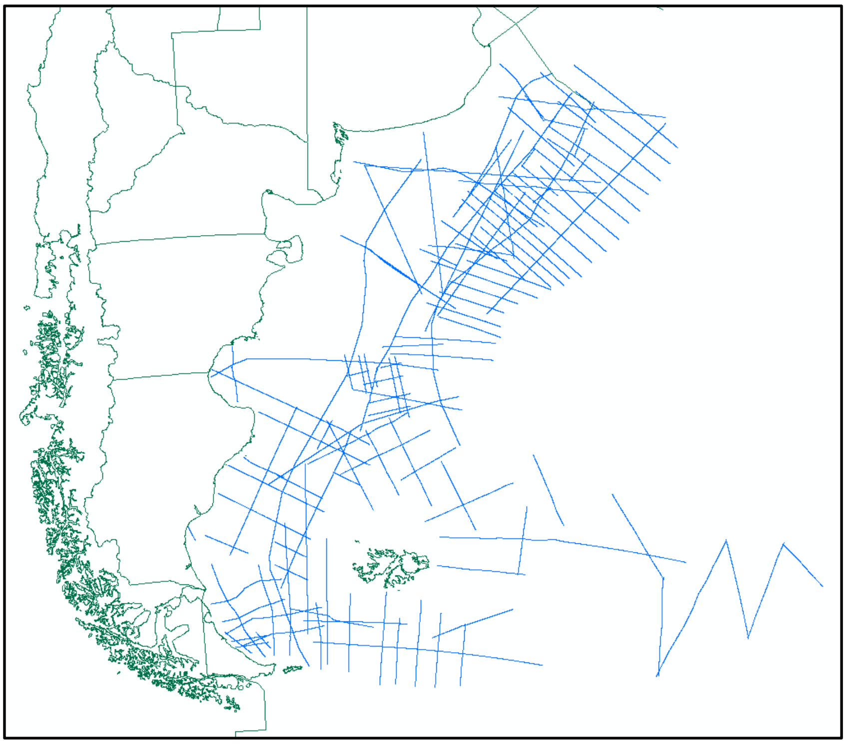


Fig. I Shapefiles map, regional lines

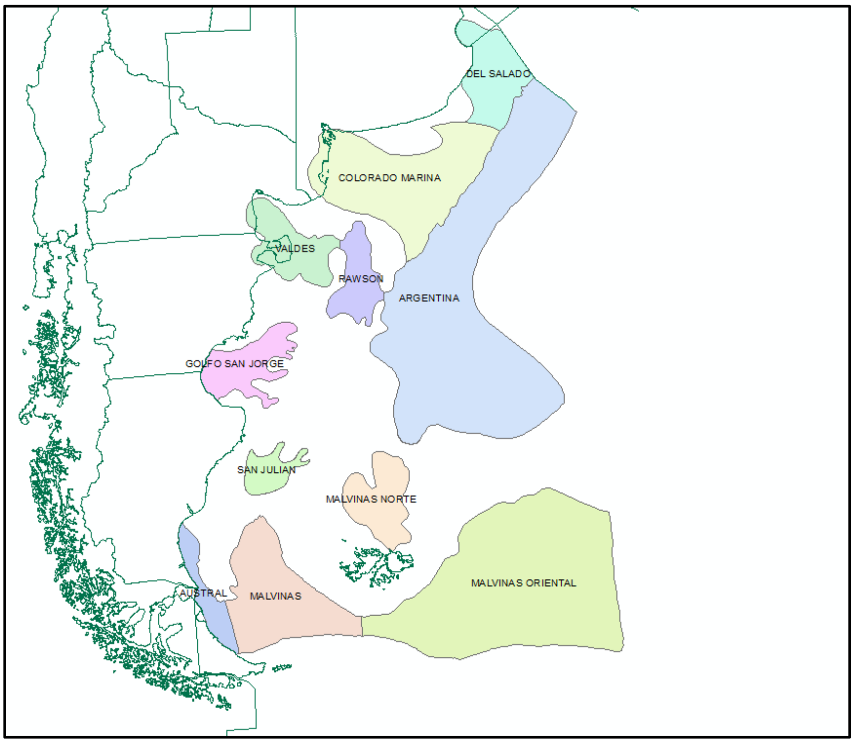


Fig. J Shapefiles map, basins

Processing sequence overview

The quality of the outcomes relies upon the original quality. Many cases showed noticeable improvements, others were more moderate. Average behaviors are illustrated on Fig. K and Fig. L. Conversely, some original data were of high quality per se; hence, the applied processing sequence was kept minimal. The overall aim was to achieve homogeneity and the best possible quality while validating and standardizing coordinates and SEG-Y headers.

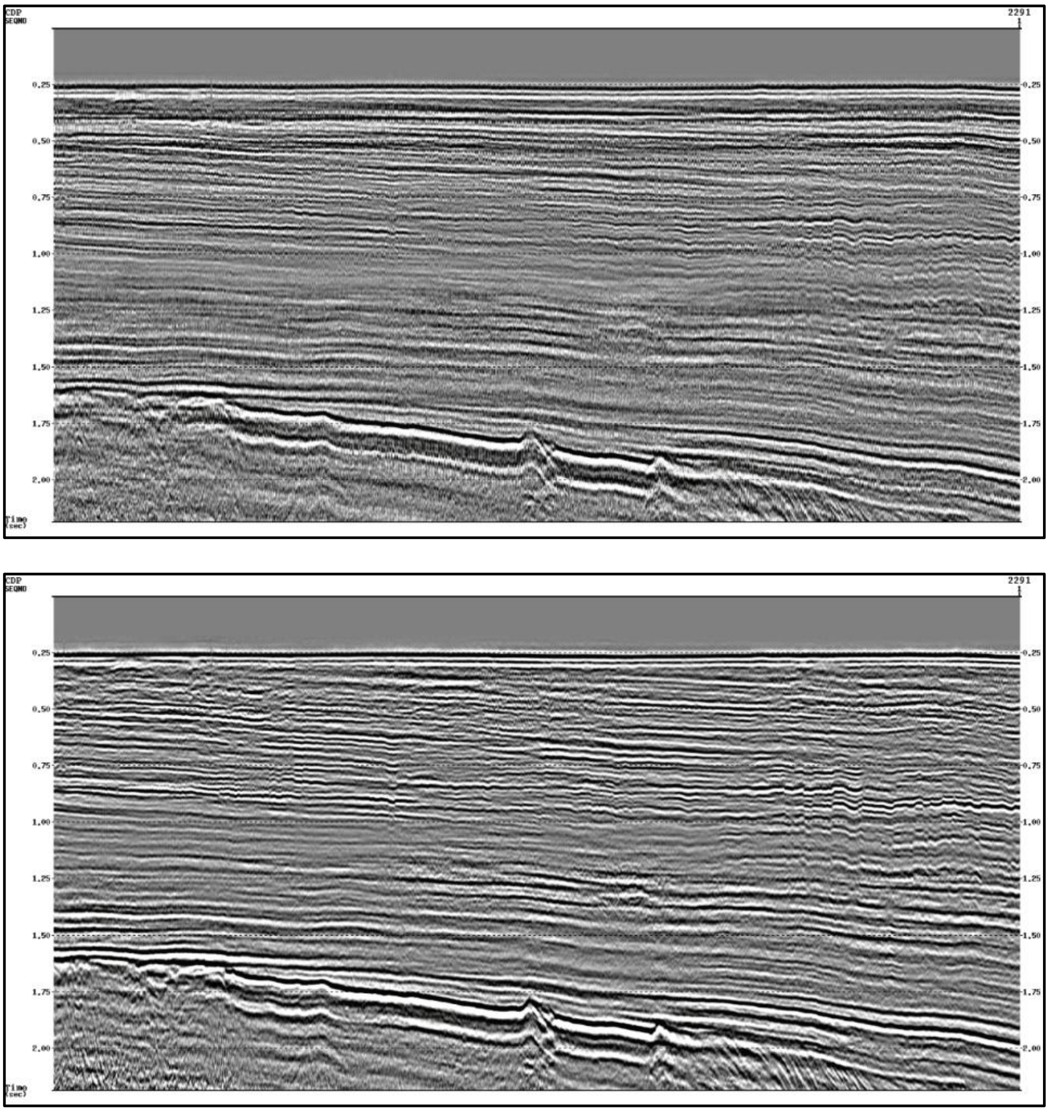
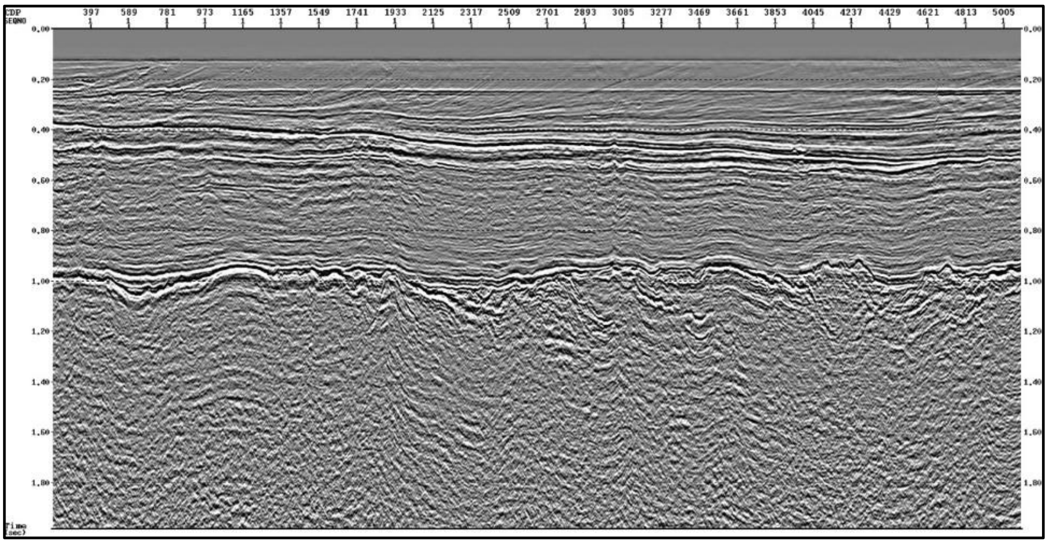


Fig. K Before (above) and after (below) processing sequence



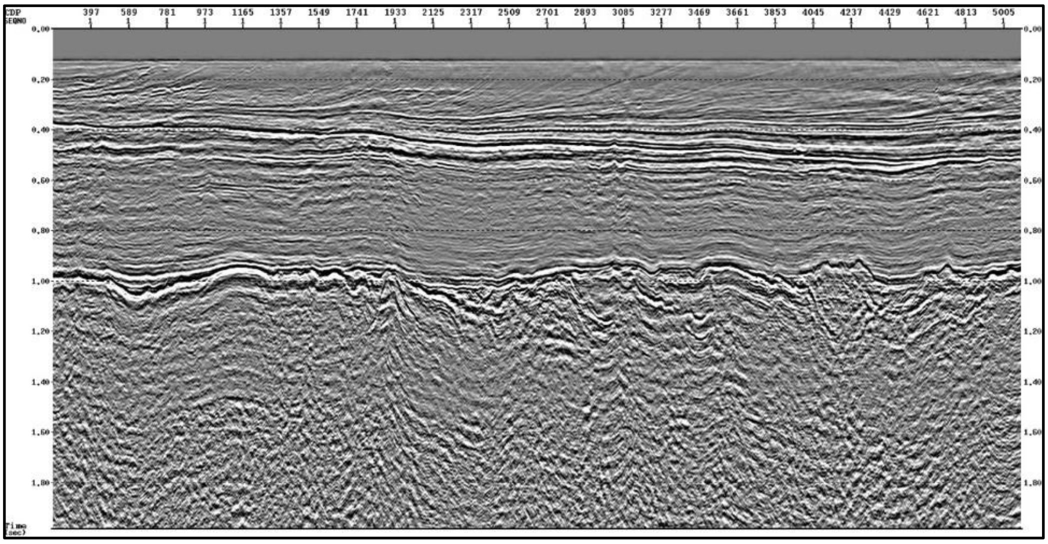


Fig. L Before (above) and after (below) processing sequence

iii. Images and observer reports

As a miscellaneous appendix we added to the database more than 1800 hard copies images and 1400 observer reports. Most images correlate with SEG-Ys already compiled in this project, others are not included as SEG-Y because non-reliable coordinates or no coordinates at all, too poor quality, the lines overlap with others with better quality or the images were recently received. Nonetheless, this information is a complementary powerful tool for further QCing. If a set of images is of interest and its metadata is available, Seiscenter offers to vectorize them into SEG-Y format free of charge with any purchase involving the area where the images belong.

This data can be easily accessed and was inserted into the descriptor file which list the processed lines, relevant processing data and relevant acquisition data; there hyperlinks to the available images and observer reports can be found.

BASIN	IMAGES	OBSERVER REPORT
REGIONAL-ARGENTINA	97	9
AUSTRAL ONSHORE	78	
AUSTRAL-MALVINAS	1389	1134
MALVINAS NORTE-SUR	1	
SAN JULIAN	1	34
GOLFO SAN JORGE	93	10
RAWSON-VALDES	54	117
COLORADO	68	31
SALADO	65	89
PUNTA DEL ESTE		
TOTAL	**1846**	**1424**

Table G, hard copy images and observer reports

III. 3D SEISMIC

A total of 20 projects were georeferenced, totaling 14180 km2 of 3D seismic. SEG-Y information is available in ten of them -11257 km2-.

SURVEY	BASIN	YEAR	OPERATOR	KM2	SGY	PROCESS REPORT	MIGRATION
ARA / ARGO / ARIES	AUSTRAL	1994	TOTAL AUSTRAL	502	YES	YES	POST-STACK
CAM-1 Y CAM-3 - HELIX	AUSTRAL	2004	SIPETROL	662	YES	YES	PRE-STACK
CARINA - TAURO	AUSTRAL	1996	TOTAL AUSTRAL	1867	YES	YES	POST-STACK
FENIX_3D	AUSTRAL	2012	TOTAL AUSTRAL	1367	YES	YES	PRE-STACK
HIDRA KAUSS	AUSTRAL	1995	TOTAL AUSTRAL	525	YES	YES	POST-STACK
MAGALLANES	AUSTRAL	1993	SIPETROL	187	YES	YES	POST-STACK
VEGA PLEYADE	AUSTRAL	1998	TOTAL AUSTRAL	645	YES	YES	POST-STACK
ARA NORTE	AUSTRAL	1998	TOTAL AUSTRAL	132	NO	NO	
CABO	AUSTRAL	0	APACHE	30	NO	NO	
CAM-2A SUR	AUSTRAL	1998	SIPETROL	211	NO	NO	
FARO VIRNEGES	AUSTRAL	1993	PECOM	86	NO	NO	
LOBO	AUSTRAL	0	YPF	68	NO	NO	
LOBO (BAHIA SAN SEBASTIAN)	AUSTRAL	0	REPSOL-YPF	56	NO	NO	
SAN SEBASTIAN	AUSTRAL	2001	PAE	76	NO	NO	
CALAMAR	MALVINAS	2015	ENARSA	1269	YES	YES	PRE-STACK
MALVINAS	MALVINAS	2006	REPSOL-YPF	2305	YES	NO	PRE-STACK
COLORADO_3D	COLORADO	2007	REPSOL-YPF	1928	YES	NO	PRE-STACK
CGSJM1 3D	GOLFO SAN JORGE	2005	REPSOL-YPF	311	NO	NO	
CSJM I	GOLFO SAN JORGE	2009	PAE	1654	NO	NO	
MARTA	GOLFO SAN JORGE	1998	UNOCAL	299	NO	NO	

Table H, 3D seismic

i. Input Data

1. Sort - Classification

As per our policy towards this project, 3Ds are of recent acquisition and processing, therefore we limited our tasks to sorting, compiling and accessibility checking. Some processing grids were recalculated to bring uniformity to the loading process, avoiding different references (corners, origin and angle).

3D seismic can be accessed through a single folder, its characteristics (name, basin, processing type, il-xl and bin coordinates header locations, length, SR, processing grid coordinates) are detailed and hyperlinks to SEG-Ys and Reports can be found.

Seiscenter S.A.

2. Shapefiles

- 3D_TOTAL (General)
- 3D_DATA (Available 3D cubes)
- 3D_NODATA (Non-available 3D cubes)

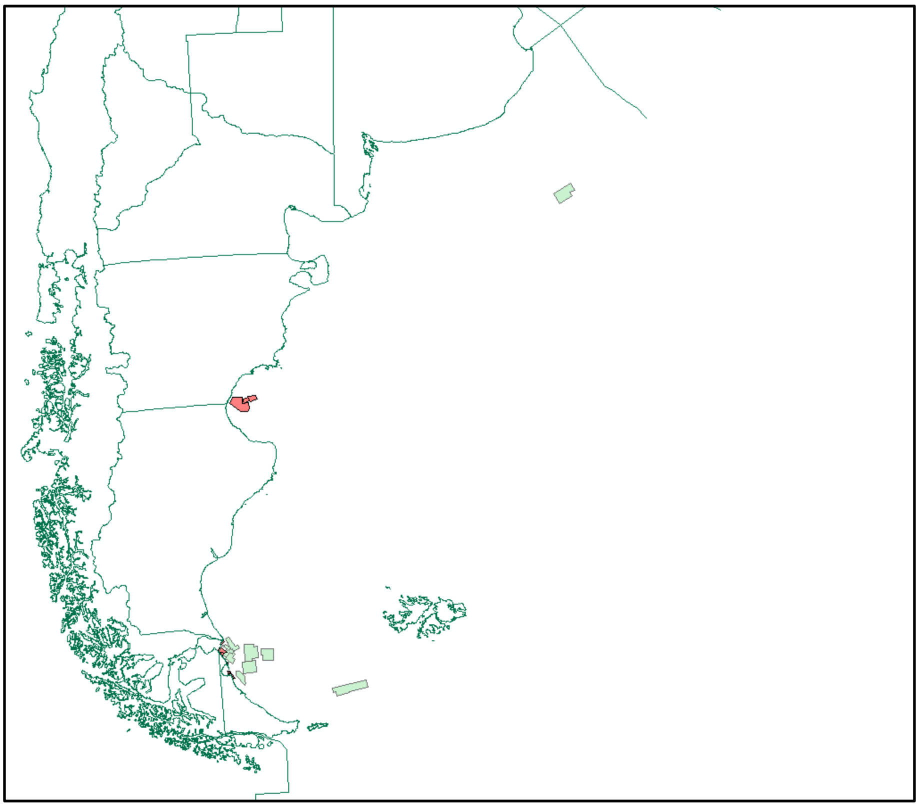


Fig. M shapefile map 3D_DATA (green) y 3D NO_DATA (red)

Seiscenter S.A.

IV. WELL DATA

A total of 496 locations were collected, 65% of which have reports and/or log information.

BASIN	TOTAL BASIN	OFFSHORE					ONSHORE				
		TOTAL BASIN OFFSHORE	REPORT		LOGS		TOTAL BASIN ONSHORE	REPORT		LOGS	
			YES	NO	YES	NO		YES	NO	YES	NO
AUSTRAL	**398**	250	132	118	134	116	148	54	94	131	17
MALVINAS	**21**	21	18	3	19	2	0	0	0	0	0
SAN JULIAN	**1**	1	1	0	1	0	0	0	0	0	0
GOLFO SAN JORGE	**37**	31	23	8	26	5	6	0	6	0	6
RAWSON-VALDES	**2**	1	1	0	1	0	1	0	1	0	1
COLORADO	**27**	18	13	5	14	4	9	0	9	0	9
SALADO	**10**	6	1	5	4	2	4	0	4	0	4
TOTAL	**496**	**328**	**189**	**139**	**199**	**129**	**168**	**54**	**114**	**131**	**37**

Table I, well information

i. Input Data

1. Sort – Classification

Well data come from a wide range of sources and time (1945-2015). The information was sorted, classified and georeferenced, it covers a variety of formats and quality (logs in las and images, reports in pdf and images). Contents were not modified and remain as they were originally configured but a fair portion of them were extensively analyzed and served as support of our Geological-Geophysical Report (see pg. 27)

All data can be accessed through a single file, which contains detailed and relevant information (location, basin, outcome, et cetera), from there hyperlinks guide to logs and reports for each well.

2. Shapefiles

- WELL_TOTAL (General)
- WELL_ON_DATA (onshore wells with well report and/or *las* files)
- WELL_ON_NODATA (onshore wells without attached information)
- WELL_OFF_DATA (offshore wells with well report and/or *las* files)
- WELL_OFF_NODATA (offshore wells without attached information)

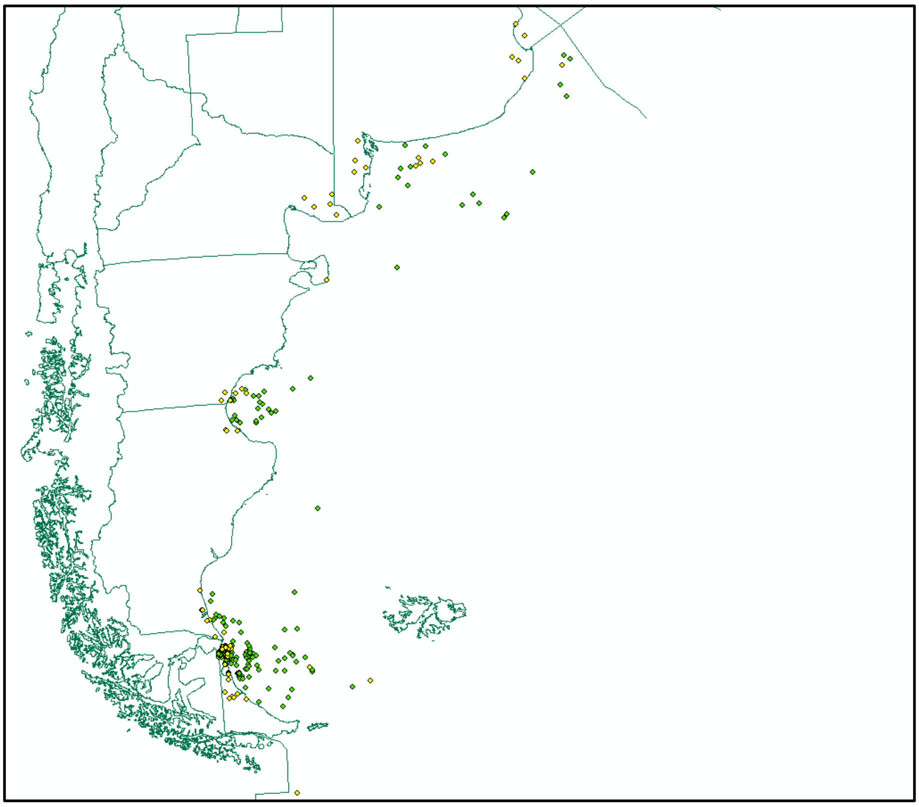


Fig. N shapefile map, WELL_ON_DATA, WELL_OFF_DATA (green) and WELL_ON_NODATA, WELL_OFF_NODATA (yellow)

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V. GEOLOGICAL-GEOPHYSICAL REPORT

The seismic and well data database was oriented and supported by a team of geologists and geophysicists, many areas were populated with improved seismic information not by a simple criterion of ‘the more the better’ but according to their strategic relevance in its geological context and contribution to a robust seismic interpretation.

An up-to-date, detailed report about petroleum systems, reservoirs, source rocks, traps, seals, main fault trends and known plays was consequently elaborated using state of the art software but basically through the insight and experience of a team of geoscientists. More than 140 pages regarding the Argentinian Offshore, basin by basin. Exploration history, well results, recommendations and remaining potential are also part of its contents.

Hydrocarbon Potential of Argentine Offshore.

Basins Argentina, Rio Salado, Colorado, Valdés Rawson, Golfo San Jorge and San Julian

Table of Content

Seiscenter S.A.

Hydrocarbon Potential of Argentine Offshore. Austral and Malvinas Basins

Table of Content

Fig. O Geological-Geophysical Report. Tables of Content

Rather than describing all the processes and efforts devoted to this report, we prefer to provide some excerpts illustrating its level of discernment and analysis.

2. Argentine Basin

Summary

The Argentine Basin covers the continental slope and deep-water areas offshore Argentina and stretches over an N-S distance of more than 1600 km. There were no exploration wells drilled yet in this basin and public information is very sparse.

The northern end of the Argentine Basin passes into the Oriental del Plata Basin, the deep-water basin of Uruguay. There is some public information available about this basin, in particular documentation provided by the Uruguayan state oil company ANCAP (www.ancap.com.uy). These is the most appropriate data to characterize the Argentina Offshore Basin.

In 2016 an exploration well, Raya 1, was drilled by Total in ultra-deep water (3411m). The well reached a total depth of 6000m, encountered target reservoir, which were water bearing. Source rock was no drilled and remain speculative.

Due to the analogy of the Argentine Basin to other basins located at the continental margins around the south Atlantic, prospectivity and potential of the Argentine Basin are logically concluded. Presence of active petroleum systems has not been confirmed in the Argentina Basin. However, well drilling on the conjugate margin of South Africa which lies opposite to the Argentina Basin, suggesting an active petroleum systems may be present. Companies accepting the challenge of exploring in deep/ultra-deep water are expected to engage in the exploration of this basin. Regional studies are necessary in order to assess the potential and identify and rank the most prospective areas of this very large basin.

2.1. Introduction and Regional Context

The Argentine Offshore Basin is part of the large group of marginal basins generated as a result of the fragmentation and break-up of the Gondwana supercontinent and the subsequent opening of the Atlantic Ocean. The separation of South America and Africa started with the formation of a rift system, in the Jurassic, which subsequently evolved towards passive marginal basins (Morales et. all, 2017).

The Atlantic margin can be divided into several provinces, the boundaries of which have been defined according to different geological and tectonic criteria. According to Moulin et al. (2005), the Atlantic Ocean can be divided into four major segments separated by large fracture zones (Figure 2.1). These segments are:

- Malvinas Segment, located to the SE of the Malvinas–Agulhas Fracture Zone (FAFZ)
- Austral Segment developed between the FAFZ and the Rio Grande Fracture Zone (RGFZ)
- Central Segment, which extends north of RGFZ to the Ascension Fracture Zone (AFZ)
- Equatorial Segment, which develops from the AFZ to the Marathon Fracture Zone (MFZ).

The Austral and Central segments include several sedimentary basins, from the Potiguar Basin in the Brazilian offshore to the Rawson Basin, offshore Argentina. In these segments, the extension and opening occurred from south to north during the Jurassic–Early Cretaceous. Consequently, the different phases and unconformities became progressively younger towards the north (Moulin et al. 2005).

The Argentine Offshore Basin is bounded (and partly includes) the South American continental slope in the west, its eastern limitation being the slope of the Mid-Atlantic Ridge. It is located in the Austral Segment. It is bounded by the Rio Grande Plateau to the north and to the south by the Agulhas-Malvinas fracture zone. Several prominent transfer/fracture zones intersect the Argentine Basin in an E-W direction (Figure 2.1). In the Austral segment, a group of NW–SE-trending failed rift basins developed perpendicular to the continental margin. The water depth of the Argentina Basin range from 200 meters until ultra-deep waters, more than 4000 meters.

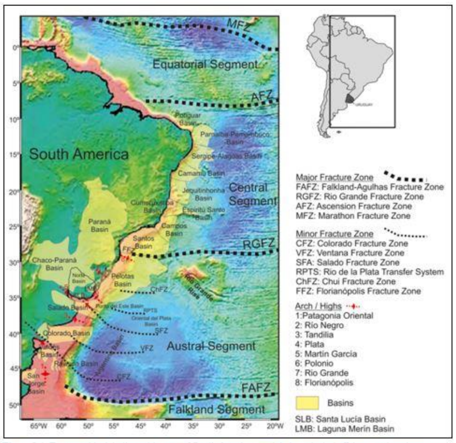

Figure 2.1: Topographical–bathymetric map of South America overlain by selected offshore and onshore basins and structural elements. Inset shows the location of the figure in relation to South America, with Uruguay highlighted in black (Morales et al. 2017).

- Direct hydrocarbon indications reported from offshore Uruguay (well Lobo 1 & Gaviotin 1)
- Occurrence of comparable petroleum systems in the genetically related Orange Basin, Namibia, and Campos Basin, Brazil.

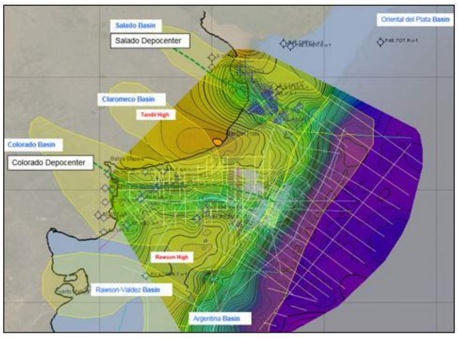

Figure 3.2: Gros post-rifth sedimentary thicknes in Salado and Colorado Basin

Since there is no known source rock in the basin, the proposed petroleum system would have been charged from organic-rich, potential shale source rocks forming part of:

- Distal lacustrine successions within Lower Cretaceous syn-rift deposits
- Marine, Aptian and Maastrichtian to Paleocene successions within thermal sag deposits.

The hydrocarbons would reside in clastics reservoirs forming part of syn-rift and thermal sag deposits, in potential structural, stratigraphic and combined stratigraphic-structural traps. Seals would consist of:

- Intra-formational syn-rift and thermal sag shales, which would form local seals
- Marine, laterally extensive Cretaceous and Tertiary shales, which would form excellent regional seals.

These regional shales accumulated during the Maastrichtian-Paleocene transgression, and Tertiary passive-margin, transgressive-regressive depositional cycles.

3.2.1 Reservoirs

There are no proven reservoir rocks in the Rio Salado Basin. However, syn-rift, sag, and the passive-margin sandstones are potential reservoirs in the Salado Basin.

The main potential reservoirs are Lower Cretaceous syn-rift, continental fluvial-alluvial sandstones and conglomerates of the Belgrano Fm. Also, Upper Cretaceous-Paleocene coastal, deltaic, and (at the top), marine sandstones of the Chilcas Fm are potential reservoirs.

Eocene, passive margin sandstones forming part of shoreline and fluvial-deltaic facies in the proximal part of the basin, and of mass-transport deposits, slope canyon and prograding wedges, and basin-floor submarine-fan systems, are also regarded as potential reservoirs.

SALADO BASIN			
ROCK STRATIGRAPHIC UNITS		TIME STRATIGRAPHIC UNITS	TECTONIC STRATIGRAPHIC UNITS
PIPINAS/ENTRE RIOS Fm.		Pliocene	Passive Margin
VALERIA/PARANA Fm		Miocene	
GENERAL PAZ/LOS CARDOS Fm		Eocene / Ologocene	
BASAMENTO	CHILCAS FM	Upper Cretaceous /Paleocene	Sag / Drift
	BELGRANO Fm	Mid/Lower Cretaceous	Syn Rift
BASAMENTO		Jurasic / Paleozoic	Pre-Rift / Rift

Figure 3.3: Generalized stratigraphic column of Salado Basin

3.2.2 Source Rocks

No source rocks were penetrated in the wells drilled in the basin. Similarly, no source rocks were recognized, on samples from offshore wells Lobo 1 and Gaviotin 1, in the Punta del Este Sub-basin. Minor oil shows were reported in two wells onshore and some residual oil in an offshore well (Davidson, et all 2016) in the Salado Basin, however potential source rock is not mentioned. For the nearby Colorado Basin and comparable geological conditions, potential syn-rift source rocks are reported.

Since there is no known source rock in the basin, the potential source rocks could forming part of lacustrine successions within Lower Cretaceous syn-rift deposits and / or marine, Aptian/Maastrichtian to Paleocene successions within thermal sag deposits.

As no discoveries exist in the basin, there are no proven migration pathways. Potential pathways are vertically along the main faults, and horizontally across faults and along carrier beds into the potential reservoirs. Main fault pathways are sparse to non-existent in the sag and passive-margin deposits, as most faults terminate upwards at the break-away unconformity separating syn-rift and thermal sag deposits.

In the 2000´s, COPLA *(Comisión Nacional del Límite Exterior de la Plataforma Continental Argentina)* conducted a regional survey and acquired some 6,800 km of seismic, part of they in the Salado Basin.

The other wells were drilled between 1969 and 1973, all were plugged and abandoned. Just minor gas shows was described in the well General Paz (total depth 3464 at lower Cretaceous). Since 1994 there was no exploration drilling activity, just little additional 2D seismic was acquired by YPF (7000 km in 1994/5) and in 2008, 10500 km of 2D span seismic was acquired by GTX (Figure 3.5)

WELL_NAME	ALT_WNAME	TCH_STAT	CONTENT	SPUD	OPERATOR	BASIN_NAME	ELEV_REF_M	TD_M	WATER_DEPTH
Samborombon Sur 3	S.S.SS-3	Plugged & abandoned	Dry well	1969	SUN	Rio Salado Basin	0.00	840.00	20.00
A-1	RC.U.A-1	Plugged & abandoned	Dry well	1969	UNOCAL	Rio Salado Basin	0.00	1698.00	80.00
Dorado 1	RC.A.D.x-1	Plugged & abandoned	Dry well	1994	AMOCO	Rio Salado Basin	0.00	3139.00	77.00
Samborombon B 1	S.U.SB.X-1	Plugged & abandoned	Dry well	1969	UNOCAL	Rio Salado Basin	15.00	1839.00	80.00
Samborombon A-1A	S.U.SA.X-1-A	Plugged & abandoned	Dry well	1969	UNOCAL	Rio Salado Basin	0.00	1731.00	15.00
Samar 1	S.S.DX-1	Junked	Oil shows in Terciary / Upper Cretaceous	1969	SUN	Rio Salado Basin	0.00	3245.00	245.00
General Belgrano	S.YPF.GB.x-1	Plugged & abandoned	Oil shows in lower Cretaceous	1948	YPF	Rio Salado Basin	15.00	4012.00	0.00
Pipinas	S.KERR.P.x-1	Plugged & abandoned	Dry well	1968	KERR	Rio Salado Basin	2.00	1612.00	0.00
Las Chilcas	S.Sig.LCh.X-1	Plugged & abandoned	Dry well	1969	SIGNAL	Rio Salado Basin	5.00	4081.00	0.00
Los Cardos	S.Sig.LC.X-1	Plugged & abandoned	Dry well	1970	SIGNAL	Rio Salado Basin	4.00	2959.00	0.00
Valeria Del Mar	S.Sun.VM.X-1	Plugged & abandoned	Dry well	1971	SUN	Rio Salado Basin	17.00	3914.00	0.00
General Paz	S.YPF.GP.x-1	Plugged & abandoned	Gas Shows in Terciary and Upper Cretaceous	1974	YPF	Rio Salado Basin	21.00	3964.00	0.00
Lobo	PdE.CHEV.L.x-1	Plugged & abandoned	Gas shows in Lower Cretaceous	1976	CHEVRON	Punta Del Este	0.00	2714.00	30.00
Gaviotin	PdE.CHEV.G.x-1	Plugged & abandoned	Hydrocarbon Indicators in Lower Cretaceous	1976	CHEVRON	Punta Del Este	0.00	3632.00	70.00

Figure 3.4: Table showing basic data of wells drilled in the Salado Basin

All the wells drilled in the basin were reported dry. The only indications for the presence of hydrocarbons were recorded in the Uruguayan wells (Lobo and Gaviotin), the Samar (oil shows, offshore) and the General Paz (minor gas, onshore).

The main phase of hydrocarbon exploration in the Rio Salado Basin was from 1969 to 1973, when most of the 13 exploration wells in the basin were drilled. In 1989 licenses were awarded again and exploration activities resumed. These activities ceased a significative positive residual Bouguer anomaly after the drilling of another dry well by Amoco, Dorado 1. Since then there was no more drilling in the basin. A new license round, including the deep-water area of the Rio Salado Basin has been announced by the Argentinian government for 2018/2019.

3.5 Discussion

The information publicly available about the Salado Basin is very sparse, which renders the assessment of remaining prospectivity and exploration potential difficult. Negative results of thirteen exploration wells drilled in the basin, and the long period of inactivity don't constitute an encouragement for future engagement in exploration activities. However, the basin is considered under explored, and most of the wells were drilled 40-50 years ago, on data bases not necessarily adequate for conclusive exploration in a complex subsurface setting.

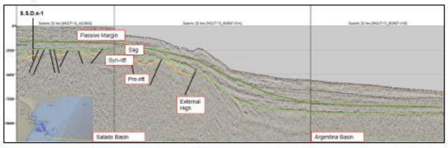

Figure 3.5: Main Structural Features of Salado Basin

Exploration in the basin is considered to be of moderate to high risk. One of the major exploration risks in all prospective plays is the uncertainty of source rock occurrence, as there is no known source in the basin. The source risk, however, decreases towards the (deeper) off-shore, which has not been explored (residual oil reported in offshore well Samar 1). Efficient seals, effective reservoirs and, in particular, the presence of economically viable traps have not been proven. These risks probably also decrease with increasing distance from the shore and increasing marine depositional influence (Figure 3.6).

The wells drilled are located onshore or on the continental shelf in shallow waters, the deep-water part of the basin has not been drilled. Depositional setting in this area is different, and analogies to other deep-water basins of the south Atlantic margins may upgrade this area, and the transition zone into the Argentine Basin, in terms of prospectivity.

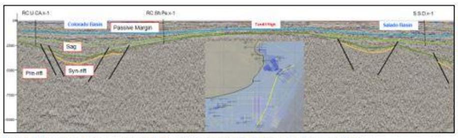

Figure 3.6: Seismic section showing the relation between the Salado and Colorado Basins

The genesis of the Salado Basin is close related with the Colorado Basin, both related with the opening of the South Atlantic Ocean in the Late Jurassic – Early Cretaceous. They are orientated in a NW-SE direction and separated by the Tandil High (Figure 3.7). Then the exploration potential of these two basins should be equivalent

3.6 Remaining Exploration Potential

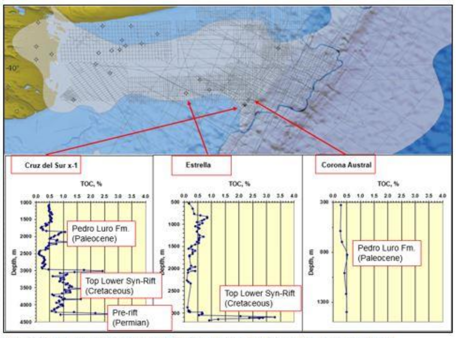

Figure 4.5: TOC samples from Cruz del Sur, Estralla and Corona Austral wells in Colorado Basin

The Colorado Fm was deposited in fluvial, lacustrine and shallow marine environments during the thermal sag stage. It is subdivided into the upper, middle, lower and basal informal units. Marine and lacustrine shales are potential source rocks in the basin, especially those in the basal unit. Vitrinite reflectance from the Colorado Fm. has a Ro of 0.7% at a depth of 2,800 m. The spore color index (SCI) ranges from 2.5 to 3.0, determined in wells Puelche 1 and Ranquel 1 (Figure 4.5).

Bathyal shales and mudstones of the Pedro Luro Fm are not thermally mature. In well Corona Austral 1, TOC contents of up to 1.35% indicate some source rock potential, but these shales could become richer in kerogen in the basin's depocenters. The formation consists pre-dominantly of deep marine shales and mudstones. However, these shales will not be thermally mature. Determinations of SCI struck values of 1.5 to 2.0. Gas chromatography in well Corona Austral 1 shows a maximum of 45,978 ppm (C1 90% and C2-C3 10%).

Preliminary results from 3D petroleum systems model indicate that although syn-rift and early Cretaceous source rock intervals may be depleted in the central areas of the basin, an active kitchen from the Aptian SR may be present below the slope areas. Hydrocarbon migration path-ways predicted by the 3D model (hybrid method) coincide with the interpreted seismic chimneys underlying the observed seabed slope pockmarks. Hence, the results indicate that thermogenic gas may be currently generated in the distal slope of the basin from mature early post-rift source rocks within the Early Cretaceous (Aptian) sequences and migrates vertically, due to seal failure, through the stratigraphic column (Anka et al, 2014). This migrating thermogenic gas is feeding the seafloor pock-marks and gas chimney features identified in the distal slope of the basin, although up-dip lateral migration along strati-graphic layers to the more proximal slope areas cannot be ruled out. (Figure 4.6).

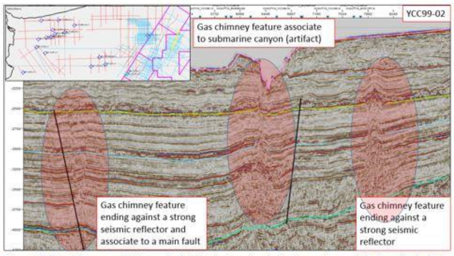

Figure 4.6: Gas chimneys and others seismic direct hydrocarbon Indicators are frequents in the seismic data. Some gas chimneys are clearly artifacts (in this case relate with submarine canyons), but others are more encourage DHIs since the feature ending against a strong reflector

4.2.3 Seals

Potential seals have been recognized throughout the stratigraphic column in the Colorado Basin. The basal shale and/or evaporate succession in the Colorado Fm. is a good seal candidate. Shales in the Pedro Luro Formation (Paleocene) were deposited during a regional transgression, serving as important regional seal rocks. In addition, the lower section of the passive margin sequence of the Elvira Formation (Eocene) might serve as local and/or regional seal.

The Hendidura Fm. was deposed in fluvial, lacustrine, deltaic, and marine environments, of which the fine-grained shale and mudstone deposits are potential local intraformational seals.

The Fortin Fm was deposited during the syn-rift stage, and the interbedded shales and mudstones are potential local seals and those in the upper section of the Fortin Fm may provide an effective regional top seal.

WELL_NAME	ALT_WNAME	TCH_STAT	CONTENT	SPUD	OPERATOR	BASIN_NAME	ELEV_REF_M	TD_M
Onbucta 1	RC YPF O x-1	Plugged & abandoned	Dry well	1948	YPF	Colorado Basin (onshore)		1836.00
Pedro Luro 1	RC YPF PL x-1	Plugged & abandoned	Dry well	1946	YPF	Colorado Basin (onshore)		3278.00
Los Gauchos 1	RC YPF LG x-1	Plugged & abandoned	Dry well	1961	YPF	Colorado Basin (onshore)		2001.00
La Blanquada 1	RC YPF LB x-1	Plugged & abandoned	Dry well	1960	YPF	Colorado Basin (onshore)		944.00
Oyola 1	RC YPF OY x-1	Plugged & abandoned	Dry well	1960	YPF	Colorado Basin (onshore)		861.00
Elvira 1	RC YPF E x-1	Plugged & abandoned	Dry well	1960	YPF	Colorado Basin (onshore)		953.00

Figure 4.9: Onshore wells on Colorado Basin

WELL_NAME	ALT_WNAME	TCH_STAT	CONTENT	SPUD	OPERATOR	BASIN	ELEV_REF_M	TD_M	WATER_D4
Cruz del Sur 0001	RC U CdS x-1	Plugged & abandoned	Non commercial Oil	1994	UN TEXAS	Colorado Basin	0.00	4288.00	0.00
Corona Austral 1	RC U CA x-1	Plugged & abandoned	Minor Oil Shows	1995	UN TEXAS	Colorado Basin	0.00	3724.00	308.00
Estrella 1	RC U E x-1	Plugged & abandoned	Dry well	1995	UN TEXAS	Colorado Basin	0.00	3545.00	0.00
BB-I-Bx 1	RC P BB-I-BX-1	Plugged & abandoned	Dry well	1970	PHILLIPS	Colorado Basin	15.00	2965.00	150.00
BB-I-Cx 1	RC P BB-I-CX-1	Plugged & abandoned	Dry well	1970	PHILLIPS	Colorado Basin	0.00	1918.00	50.00
BB-I-Dx 1	RC P BB-I-DX-1	Plugged & abandoned	Dry well	1970	PHILLIPS	Colorado Basin	0.00	1196.00	50.00
BB-I-Ex 1	RC P BB-I-EX-1	Plugged & abandoned	Dry well	1970	PHILLIPS	Colorado Basin	0.00	1340.00	50.00
BB-I-Fx 1	RC P BB-I-FX-1	Plugged & abandoned	Dry well	1970	PHILLIPS	Colorado Basin	0.00	980.00	35.00
BB-I-Gx 1	RC P BB-I-GX-1	Plugged & abandoned	Dry well	1970	PHILLIPS	Colorado Basin	0.00	1615.00	35.00
BB-I-Hx 1	RC P BB-I-HX-1	Plugged & abandoned	Dry well	1970	PHILLIPS	Colorado Basin	0.00	3240.00	35.00
El Delfin 1	RC H ED x-1	Plugged & abandoned	Dry well	1970	HUNT INT	Colorado Basin	15.00	2514.00	115.00
El Pinguino 1	RC H EP x-1	Plugged & abandoned	Dry well	1970	HUNT INT	Colorado Basin	0.00	2268.00	80.00
La Ballena 1	RC H LB x-1	Plugged & abandoned	Dry well	1970	HUNT INT	Colorado Basin	15.00	4403.00	115.00
BB-III-Ax 1	RC P BB-III-AX-1	Plugged & abandoned	Dry well	1969	PHILLIPS	Colorado Basin	0.00	4026.00	35.00
Puelche 1	RC YPF PU ES-1	Plugged & abandoned	Dry well	1977	YPF	Colorado Basin	32.00	4063.00	262.00
BB-I-Ix 1	RC P BB-I-IX-1	Plugged & abandoned	Dry well	1970	PHILLIPS	Colorado Basin	0.00	858.00	20.00
Ranquel 1	RC YPF RA ES-1	Plugged & abandoned	Dry well	1977	YPF	Colorado Basin	30.00	4466.00	312.00
Pejerrey 1	RC Sh Pe x-1	Plugged & abandoned	Minor Oil Shows	1997	SHELL AR	Colorado Basin	0.00	3002.00	289.00

Figure 4.10: Offshore table of offshore Colorado Basin wells

The offshore exploration activity began in the 1960´s with the 2D seismic acquisition. Philips and YPF was active at this time and they drilled the Bahia Blanca wells (total of nine well dry in shallow waters)

In the early 1970´s Hunt acquired more 2D seismic and drilled three additional dry wells also in shallow waters.

In 1977 after a new 2D seismic acquisition, YPF drills the wells Puelche x-1 and Ranquel x-1 at deeper waters to test seismic anomalies in the Tertiary column. The anomaly turned out to be an intrusion, no source rock penetrated although gas rereading was informed in Colorado Fm.

In the 1990´s Union Texas and Perez Companc acquires acquired 7000 km of 2D seismic in the eastern flank of the basin and drilled three wells (Cruz Del Sur, Corona Austral and Estrella). The Cruz Del Sur well tested 39° API oil in a DST. Also a good quality source rock was penetrated

In late 1990´s Shell acquired 9000 km of 2D seismic and drilled the dry well Pejerrey-1. In mid-2000´s, 2000 km2 of 3D seismic was acquired in block E-1 by YPF-Petrobras consortium but no well was drilled. In the block E-3 7500 km2 of gravimetric and magnetic data was acquired. Since then no additional exploration activities was reported (Figure 4.10).

All exploration effort in the Colorado Basin was concentrated in the western part of the basin. Eastern part of Colorado basin is considered frontier exploration area with no exploration drilling until now.

4.5 Discussion

To date no commercial discoveries have been made in the Colorado Basin. However, the generation of hydrocarbons and the ingredients for working petroleum systems have been proven by the wells drilled in the basin. They occur in stratigraphic intervals from Paleozoic to Tertiary and developed during different stages of basin development.

Source rocks were drilled in pre-rift, syn-rift and post-rift sequences. They are of very variable quality but have overall potential of feeding a petroleum system. There is no information about how much hydrocarbons could have been fed into the system by the different potential source rock sequences.

Shows and recovery of hydrocarbons in well proved maturity, generation and expulsion of hydrocarbons, and 3D petroleum systems models indicate hydrocarbon generation from different source intervals. At present, these potential source rocks are at an oil window at the shelf and in a gas window at the slope of the basin.

Potential seals have been recognized throughout the stratigraphic column in the Colorado Basin. Potential intra-formational local seals include flood plan, deltaic, and marine shales and mud-stones in the pre-rift (Hendidura Fm.), syn-rift (Fortin Fm.) and post-rift (Colorado Fm.) The basal shale and/or evaporate succession in the Colorado Fm. is a good, potentially regional, seal. Shales in the Pedro Luro Formation were deposited during a regional transgression, serving as important regional seal rocks. In addition, the lower section of the passive margin sequence of the Elvira Formation might serve as local and/or regional seal.

Well and seismic data and stratigraphic modeling identified potential reservoir rocks. These potential sandstone reservoirs were deposited in fluvial, deltaic, and shallow marine environments. The shallow marine sandstones of the Colorado Formation have good reservoir qualities and represent prime reservoir targets, in particular in the eastern part of the basin. Diagenesis and volcanics have an impact on reservoir quality throughout the basin, pre-dominantly on the deeper buried syn-rift deposits.

Structures in the Colorado Basin developed during the pre-rift, syn-rift, and post-rift tectonic phases. The dominant structural styles developed during the syn-rift phase from Late Jurassic to Early Cretaceous. Both extensional and compressional / transpressional structures were formed primarily during the pre-rift and syn-rift phases, with partial reactivation of existing faults and structures. The syn-rift / younger sediments are less affected by faulting, both number and throw of faults decrease. There are no detailed structure maps or prospect maps available which may indicate structure size or potential hydrocarbon volumes. Stratigraphic traps are probably existing at all stratigraphic levels. The quantification of stratigraphic

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Scotia Ridge. The tectonic evolution of the basin started in the Jurassic with rifting processes associated to the Gondwana break up. During the Cretaceous a generalized thermal subsidence (sag) caused a regional marine ingression. At around the Cretaceous-Tertiary boundary, a process of transtensional deformation took place originating the beginning of a foreland basin phase. The basin tilts and the north east flank was uplifted. Strike slip and direct faulting occurs in the south sector. At the Upper Eocene, a transpressive regime took over. The south sector of the basin was uplifted by faulting and folding with an east to west alignment, constituting an Andean orocline. Seismic and well data show that the stratigraphic column of the Austral Basin is also developed beyond the Rio Chico High resulting the Malvinas Basin a continuation of that one. Almost all the seismic reflectors can be followed from one basin to the other through the sector south of Rio Chico High. The occurrence of an active petroleum system has been documented by the oil obtained from wells in the western sector of the basin (Galeazzi, 1998).

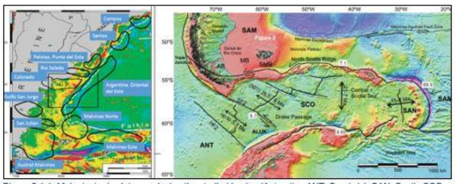

Figure 2.1.1: Major tectonic plates enclosing the studied basins (Antarctica ANT, Sandwich SAN, Scotia SCO, South America SAM), with directions of motions at boundaries, showing velocity of plate motion relative to a fixed Scotia plate from Thomas et al. (2003), and summary of ocean floor ages and directions of opening in the Scotia Sea region from Barker (2001), Eagles et al. (2005) and Livermore et al. (2005). Abbreviations are AB: Austral basin; HFZ: Hero Fault Zone; MB: Malvinas basin; SFZ: Shackleton Fault Zone; SMB: South Malvinas basin; SSR: South Scotia Ridge. Basemap is bathymetry predicted using satellite altimetry (Sandwell and Smith, 1997).

Biomarkers of the recovered oil shows a good correlation with the Lower Cretaceous marine shales. This source rock has a regular to good generating potential with values of TOC between 1 and 3% wt. and HI near 400 mgHC/gTOC (Nevistic et al., 1999). Continental Jurassic shales, proven source rock in the Austral basin, could also be present in the Malvinas basin being part of a speculative petroleum system. Upper Cretaceous (Maastrichtian) as well as Eocene shales could be interpreted as belonging to hypothetical petroleum systems. In addition to hydrocarbon generation, sea bottom cores have provided gas samples which were interpreted as having a thermogenic origin (Figueroa et al., 2005). A basinwide seismic-stratigraphic model and well data were the basis for building a petroleum system model of the basin. This suggests that at deeper positions of the basin the expulsion of oil could have started as early as Eocene times and continues today at shallower positions (Sylwan et. all, 2007). Cretaceous and Tertiary reservoirs are likely to present the same quality as they show in the Austral basin. The Austral and Malvinas basins seem to be a unique and single basin separated partially by the Rio Chico High. This is supported by seismic and well data. Being the stratigraphy almost the same, it is very encouraging that this analogy could also be valid when regarding commercial hydrocarbon accumulations.

2.1.1 Stratigraphy and Tectonism

Four tectonic phase can be differentiate in the Austral and Malvinas basins have defined by Rodriguez (2010) and a summary of Rodriguez´s interpretation is presented here (Figure 2.1.2):

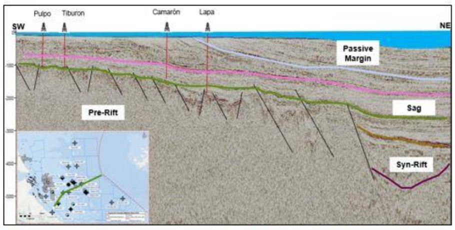

Figure 2.1.2: Schematic interpretation of the tectonic phases in Austral and Malvinas basins. Just the platform have been partialy explored but the for-land is completaly undrilled

- Pre-Rift: Permian / Late Triassic. Foreland Process. This the pre Atlantic opening and they are relictic sedimentary , metamorphic and igneous rocks, include in the term Basement
- Syn-Rift: Jurassic / Early Cretaceous. Crustal reorganization leading to South Atlantic Opening related with the Gondwana break out. The rifting is related with acid volcanism. This stage also include the development of grabens and hemi-grabens filled by volcanic and tuff rocks. And from lithologic point of view theses rocks are known as Serie Tobifera. The syn-rift stage ended with a massive transgression of oxfordiana-kimmeridgiana age and development of fluvial deltaic Springhill Fm which include good quality reservoirs
- Sag. Early Cretaceous, initial phase of thermal subsidence. It develops on a continental crust substrate and shows sag geometry, and marks the end of the tectonic activity of the syn-rift stage. The Springhill Fm is the beginning of this stage
- Fore-Land or Post-Rift: Late Cretaceous / Cenozic Characterized by thermal subsidence and Atlantic open circulation. This stage have several episodes, the first deformation episode correspond to the Barremiano - Aptiano which is related with a continentalization in the north of the basin. The second episode is the Cenomaniano y Coniaciano age and is related with basalt volcanism. The las two episodes are

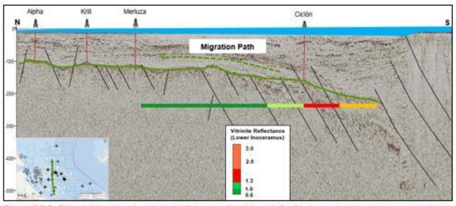

Figure 2.2.3: Seismic Line showing the long distance migration path for the lower cretaceous source rock from the basin depocenter (in the south) in Malvinas basin. The maturity was calculate by modeling using the well sampled Austral basin plus few samples from Malvinas basin

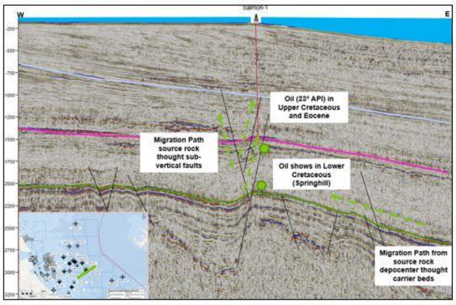

Figure 2.2.4: Seismic section throught the Salmon-1 well showing the faulted anticline where the well were drilled and the migration paths

The oil and gas files in Upper Cretaceous (and even Tertiary) reservoirs (like Maria Ines and Puesto Peter in onshore Austral basin or the noncommercial discovery Salmon-1 in Malvinas basin) could be charged by vertical (near verticals faults) migration from the lower cretaceous source rocks (Figure 2.2.4).

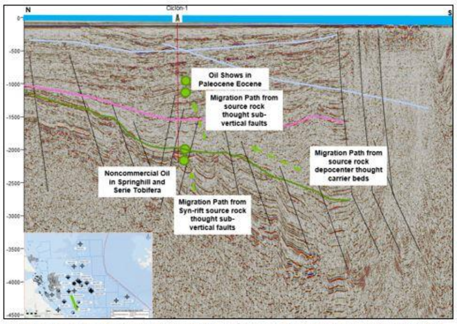

Figure 2.2.5: Seismic line showing the location of the Ciclón well. The Ciclon well tested oil in Sprinhill and in Serie Tobire while oild shows was also revealin the Paleocene and Eocene reservoirs. The oil in the Tobifera (and Spmghill?). Formation is probably relatd with a Jurrassic source rock located in the adjacent hemi-graben. Oil in Spmnghill and Terciary reservoirs would be related with the lower Cretaceous source rocks

The source rocks within the Serie Tobifera Fm. are associated with the depocenters of hemi-grabens of the syn-rift tectonic stage, for this reason the distribution and thickness are highly variable and limited in space. There are no evidence of long distance migration from this source rock, the petroleum system Serie Tobifera - Serie Tobifera/Springhill Fm is proven in Austral basin (for instance oil field Angostura) and in the Malvinas basin thought the non-commercial discovery Ciclón-1 well and in South Malvinas Basin by the Darwin discovery (Figure 2.2.5).

2.2.3 Seals

In different stratigraphic levels, seal rocks locally and regionally developed are present. There are Syn-rift lacustrine deposits as well as early drift distal marine deposits, and among the latter, marine deposits of the Paleocene transgression.

The main regional are the bathyal shales of the seal is the Pedro Luro Formation. Also, exist potential intra-formational local seals include flood plan, deltaic, and marine shales and mudstones in the Syn-rift Fortin Formation as well as into the Post-rift Colorado Formation. All seals integrity issues are related to the main rift faults.

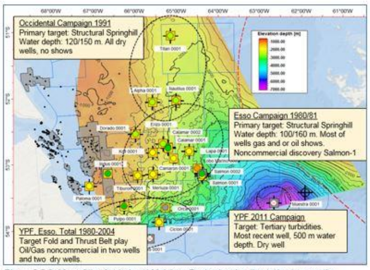

Figure 2.3.3: Map of the Austral and Malvinas Basin showing the main steps on the exploration history

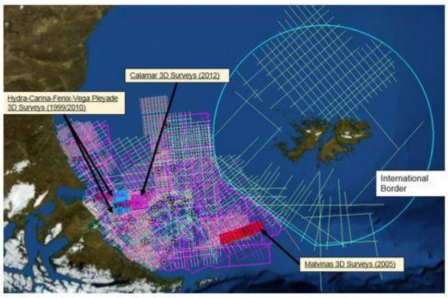

Figure 2.3.4: Vintage 2D and 3D seismic data in offshore Austral Basin and Malvinas Basin

Summarizing in theses pulse exploration activities 19 wells were drilled resulting that 4 wells showed non-commercial oil pay with significant oil shows in a further 4 wells. The eastern flank of basin is undrilled (Figure 2.3.3).

Austral and Malvinas basins (and adjacent area) in the offshore Argentina are covered by about 200.000 km of 2D seismic data in water depth between few meters to over 4000 m and about 3200 km2 of 3D seismic. All of this data belongs to the public domain. 2D seismic acquisition in the area begun at late 1960´s and there are several data vintage (more than 20) until these days. Different data vintage means different acquisition parameters / technologies and different quality. There are also about 2500 km2 of 3D seismic data (recorded between 1999 and 2010) available in shallow waters near to de cost of Tierra del Fuego over the production gas fields Hydra, Carina, Vega Pleyade and Fenix. In addition, the Argentina National Oil Company, Enarsa acquired 400 km2 of 3D seismic in the vicinity of wells Calamar-1 and Calamar-2 in 2012. The only one 3D seismic survey in the Malvinas Basin have acquired by YPF in 2005 (Figure 2.3.4)

In general, the seismic data quality is variable from good to very poor quality. The data preservation is also variable and poor. There are data available only in paper (with scanned version is available). In some case, a digital version (SEGY format) is available of the stack version. Other cases include field information (tapes and observer reports)

The original data required considerable adjustments, editing and QC enhancement, particularly the lines navigation is a critical issue, because in many cases field data (digital records, observer logs, etc.) are not available. Special care have to be taken with the lines shot points / coordinates relation and the geographic reference system.

Dry Hole Analysis in Malvinas Basin

A dry hole analysis was performed on most of the wells drilled in the Malvinas basin. Dry Hole Analysis (DHA, also called post-well or postmortem analysis) supports the creation of reservoir, seal, charge and trap maps. The DHA try to determinate which well is a valid play tested, was it a success with mobile hydrocarbons, or was it a failure. And if so, what was the failure reason.

Failure analysis is a crucial step in finding out why and where risk elements worked or did not work in a previous exploration project. However, in play evaluation DHA does not judge on commerciality of found volumes. The DHA performed in this report shows the confidence on reservoir, seal, charge or traps in a color scale from one (green) and five (red) (Figure 2.3.5)

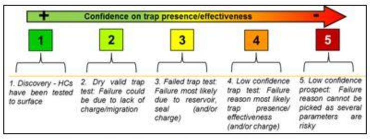

Figure 2.3.5: Proposed Failure Reason Scheme For Malvinas Basin

Regarding the traps, they are the main cause of well failure. The color code reflect the case of success, when the HCs produced to surface to the worse case of dry appraisal well of proven structure. Intermediate considered case was, dip-closed, fault-closed or combined stratigraphic-fault trap with prospect map but no hydrocarbons produced to surface (Figure 2.3.10).

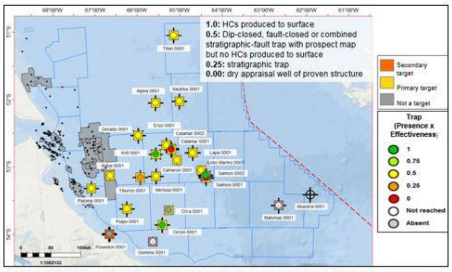

Figure 2.3.10: DHA for drilled wells in Malvinas Basin (Springhill Fm) showing results regarding traps (in terms of presence x effectiveness)

The charge failure factor shows from the well hydrocarbon testing in Salmon-1, Calamar-1 and Ciclon-1 wells to non or weak hydrocarbon shows (for instance wells Alpha-1, Titan-1 and Nautilus-1, all located in the north of the studied area). The intermediate case are good shows in open hole measurements, shows cutting or gas picks during drilling.

The depth of burial increase to the south and the maturity is high. To the western, northern and eastern flanks of the basin become likely immature and thus require lateral migration to charge possible traps. Long distance lateral migration have proven in Austral Basin to the west. The presence of carrier beds was confirmed by drilling, but also faults throughout the section provide both lateral and vertical migration possibilities.

The oil and gas files in Upper Cretaceous (and even Tertiary) reservoirs (like Maria Ines and Puesto Peter in onshore Austral basin or the noncommercial discovery Salmon-1 in Malvinas basin) could be charged by vertical (near verticals faults) migration from the lower cretaceous source rocks.

Increasing depth of burial to south and gas shows and pays in wells as well as the presence of shallow hydrocarbon flags is seismic point out the gas risk within the basin. Western, northern and eastern flanks of the basin likely immature and thus require lateral migration which have been proved in the onshore Austral basin to the west. Likely the presence of carrier beds (Springhill Fm.), but also faults throughout the section provide both lateral and vertical migration possibilities. Basin modelling from several literature sources suggests significant segregation of charge to the west. Northern areas may not receive significant charge. The graded nature of basin provides extended charge window, hence the oil charge likely began in late Palaeogene / early Neogene, with areas still generating present day (Figure 2.3.11)

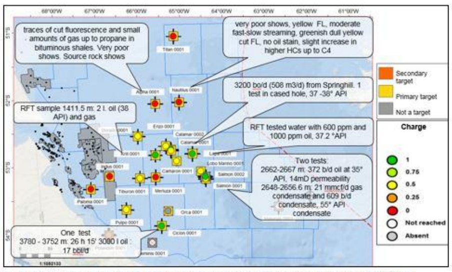

Figure 2.3.11: DHA for drilled wells in Malvinas Basin (Springhill Fm) showing results regarding charge

2.4. Discussion

The offshore part of Austral basin and the Malvinas Basin sits between prolific Austral Basin and Darwin discovery in Malvinas Sur Basin (Figure 2.4.1).

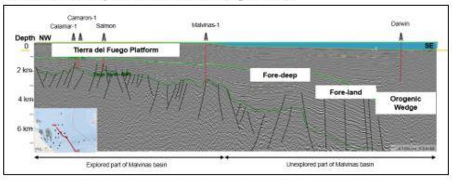

Figure 2.4.1: Regional Seimsic line from Tierra del Fuego Platform to to the Orogenic Wedge

It is worth to say that the Darwing discovery have proven a source–prone intervals were, but were found to be immature for hydrocarbon generation. The mature source rock responsible

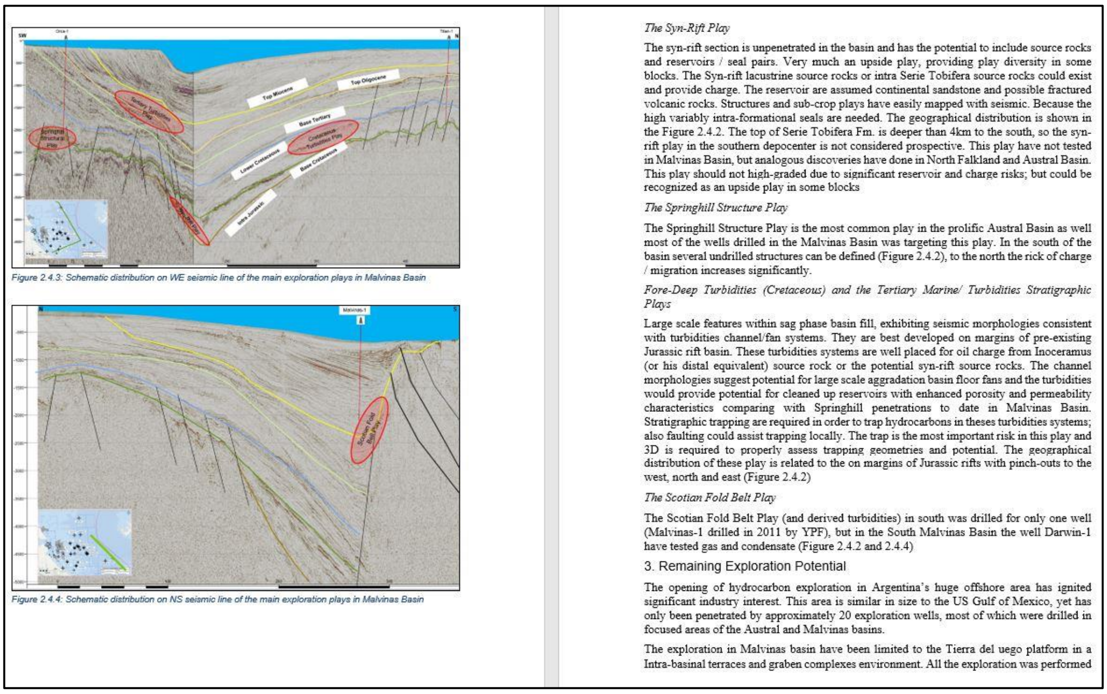

Figure 2.4.3: Schematic distribution on WE seismic line of the main exploration plays in Malvinas Basin

Figure 2.4.4: Schematic distribution on NS seismic line of the main exploration plays in Malvinas Basin

The Syn-Rift Play

The syn-rift section is unpenetrated in the basin and has the potential to include source rocks and reservoirs / seal pairs. Very much an upside play, providing play diversity in some blocks. The Syn-rift lacustrine source rocks or intra Serie Tobifera source rocks could exist and provide charge. The reservoir are assumed continental sandstone and possible fractured volcanic rocks. Structures and sub-crop plays have easily mapped with seismic. Because the high variably intra-formational seals are needed. The geographical distribution is shown in the Figure 2.4.2. The top of Serie Tobifera Fm. is deeper than 4km to the south, so the syn-rift play in the southern depocenter is not considered prospective. This play have not tested in Malvinas Basin, but analogous discoveries have done in North Falkland and Austral Basin. This play should not high-graded due to significant reservoir and charge risks; but could be recognized as an upside play in some blocks

The Springhill Structure Play

The Springhill Structure Play is the most common play in the prolific Austral Basin as well most of the wells drilled in the Malvinas Basin was targeting this play. In the south of the basin several undrilled structures can be defined (Figure 2.4.2), to the north the rick of charge / migration increases significantly.

Fore-Deep Turbidities (Cretaceous) and the Tertiary Marine/ Turbidities Stratigraphic Plays

Large scale features within sag phase basin fill, exhibiting seismic morphologies consistent with turbidities channel/fan systems. They are best developed on margins of pre-existing Jurassic rift basin. These turbidities systems are well placed for oil charge from Inoceramus (or his distal equivalent) source rock or the potential syn-rift source rocks. The channel morphologies suggest potential for large scale aggradation basin floor fans and the turbidities would provide potential for cleaned up reservoirs with enhanced porosity and permeability characteristics comparing with Springhill penetrations to date in Malvinas Basin. Stratigraphic trapping are required in order to trap hydrocarbons in theses turbidities systems; also faulting could assist trapping locally. The trap is the most important risk in this play and 3D is required to properly assess trapping geometries and potential. The geographical distribution of these play is related to the on margins of Jurassic rifts with pinch-outs to the west, north and east (Figure 2.4.2)

The Scotian Fold Belt Play

The Scotian Fold Belt Play (and derived turbidities) in south was drilled for only one well (Malvinas-1 drilled in 2011 by YPF), but in the South Malvinas Basin the well Darwin-1 have tested gas and condensate (Figure 2.4.2 and 2.4.4)

3. Remaining Exploration Potential

The opening of hydrocarbon exploration in Argentina's huge offshore area has ignited significant industry interest. This area is similar in size to the US Gulf of Mexico, yet has only been penetrated by approximately 20 exploration wells, most of which were drilled in focused areas of the Austral and Malvinas basins.

The exploration in Malvinas basin have been limited to the Tierra del uego platform in a Intra-basinal terraces and graben complexes environment. All the exploration was performed

Fig. P Geological-Geophysical Report, random excerpts

VI. DATA STRUCTURE

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