STRATIGRAPHIC AND LATERAL DISTRIBUTION OF TOC IN THE VACA MUERTA FORMATION

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PROJECT OBJECTIVES

- Determine depositional and temporal trends in accumulation of organic-rich strata in the Neuquén Basin from over 4000 outcrop samples.
- Refine thickness maps of TOC-rich intervals.
- Correlate geochemical measurements of outcrop samples to log measurements and petrophysical values.

RATIONALE

One reason why the Vaca Muerta Formation in the Neuquén Basin is the most prolific unconventional play in South America is the long-lived nature of organic-rich strata accumulation. Deposition of strata rich in Total Organic Carbon (TOC) occurred during the Late Jurassic – Early Cretaceous in the basal portion of a time-transgressive prograding shelf system. Due to the prograding nature and the evolving fill of the basin, TOC content is variable laterally and also temporally constrained. High TOC intervals are most prominent in the basal components of prograding clinoforms. In the southern part of the basin, only the oldest clinoforms are indicative of this basal component. Outcrops provide the record of the evolving basin and its organic-rich strata.

In years of field work, over 2000 m of sections in six zones along the western margin of the basin were examined. Within these sections, approximately 4000 samples were taken and analyzed for TOC, carbonate content, $\delta^{13}C_{org}$, and $\gamma-$ log. Together, these data allow for a comprehensive assessment of the distribution, and both the lateral and temporal variability of the organic-rich intervals in the Neuquén Basin.

Age	Interval	PL		SdlVM		Loncopue		PC		AT		All Outcrops		El Trapial	
		Avg TOC	MAX TOC	Avg TOC	MAX TOC	Avg TOC	MAX TOC	Avg TOC	MAX TOC	Avg TOC	MAX TOC	Avg TOC	MAX TOC	Avg TOC	MAX TOC
Valanginian	V3-V4	N/A		N/A		N/A		0.90%	**2.82%**	1.11%	**2.56%**	0.94%	**2.82%**	N/A	
Valanginian	V2-V3	N/A		N/A		N/A		1.28%	**4.07%**	1.50%	**4.92%**	1.38%	**4.92%**	N/A	
Valanginian	V1-V2	N/A		N/A		N/A		1.41%	**4.31%**	1.12%	**2.69%**	1.30%	**4.31%**	N/A	
Valanginian	B4-V1	N/A		N/A		N/A		2.60%	**9.19%**	2.16%	**6.27%**	2.48%	**9.19%**	4.34%	**10.77%**
Berriasian	B2-B4	N/A		N/A		N/A		2.60%	**6.77%**	3.16%	**6.61%**	2.74%	**6.77%**	4.92%	**8.35%**
Berriasian	B1-B2	N/A		N/A		N/A		2.45%	**6.53%**	2.41%	**4.88%**	2.41%	**6.53%**	N/A	
Berriasian	T5-B1	N/A		N/A		1.76%	**2.62%**	2.98%	**9.69%**	2.71%	**5.99%**	2.77%	**9.69%**	4.83%	**9.58%**
Tithonian	T3 - T5	N/A		0.80%	**6.00%**	3.03%	**5.51%**	2.28%	**6.01%**	2.72%	**6.95%**	1.64%	**6.95%**	6.04%	**10.52%**
Tithonian	T1 - T3	1.45%	**11.82%**	2.65%	**16.26%**	4.03%	**9.47%**	2.30%	**7.24%**	3.75%	**11.69%**	2.69%	**16.26%**	6.47%	**11.51%**

Table 1. TOC values (average and maximum) of seismic intervals, arranged by outcrop. Intervals of high TOC indicated by darker color shading.

APPROACH AND WORKFLOW

Two easily identifiable, laterally extensive, high TOC intervals, commonly refered to as "Kitchen" are found in the Middle Tithonian (T1-T3) and the Upper Berriasian (B2-B4). In outcrop, the average TOC value for the Tithonian "Kitchen" is 2.69% (Table 1), compared to 6.47% in the subsurface. In the stratigraphically higher, chronologically younger Berriasian "Kitchen," averaged outcrop values are 2.74% TOC, with 4.92% in the subsurface. Multiple individual sections that span these key time intervals will be examined to determine small scale variability of TOC, as well as determining the association of organic richness to refined depositional geometries and slope angles.

For correlating the various outcrop sections to determine time-equivalent strata we produce a sequence stratigraphic analysis in each section and combine it with biostratigraphic information. This sequence stratigraphic framework is tied to reflection horizons that cut the outcrop surface (Masaferro et al., 2014) and extrapolated to the subsurface stratigraphic horizons identified in the "Transecta Line" (Sattler et al., 2016). From this correlation, two transect lines are used to constrain the sections into the overall framework. Detailed stratigraphic logs were compiled together, and incorporated into our basinal stratigraphic framework that can now be populated with all of our geochemical measurements.

EXPECTED OUTCOME OF TOC VARIABILITY ACROSS THE BASIN

It is known that organic carbon is not concentrated at a unique horizon within the basin but the positioning of organic-rich intervals becomes stratigraphically higher and chronologically younger towards the basin center. The results presented will document the repeated occurrence of organic-rich strata in outcrops and subsurface at multiple horizons. By placing the data into a seismic and refined sequence stratigraphic framework, our latest understanding will produce a map detailing the lateral extent of TOC-rich zones on the scale of 10s to 100s of kilometers. The latest advancements in our understanding of the basin dynamics will be incorporated into our depositional model to produce a refined map documenting the extent, and thickness of high TOC strata within the Vaca Muerta Formation.

REFERENCES

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