

Spatial Distribution of Large-Scale Carbonate Buildups in a Closed Lake System, Lago Strobel, Santa Cruz, Argentina*

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Search and Discovery Article #51140 (2015)**

Posted September 7, 2015

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Houston Texas, April 7, 2014.

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Abstract

Lago Strobel, located in the Patagonian region of Argentina, has substantial carbonate buildups (precipitates) paralleling its shoreline. These deposits were investigated using satellite imagery (ASTER and Quickbird) and Digital Elevation Models (DEM). Quickbird (0.6 m pan-sharpened) imagery has detailed spatial resolution that offers the ability to recognize and quantify the carbonate-buildup morphology. Such buildups are white to light tan in color and distinctly different compared with the surrounding dark brown to black basal. This color contrast enables spectral analyses of the Quickbird data to characterize and map well exposed (coalesced buildups) to marginally exposed (separate buildups) carbonate deposits. ASTER thermal IR data has large 90 m pixels and is used to identify zones of large-scale carbonate deposits along the shore of Lago Strobel and in peripheral lakes. ASTER also collects overlapping stereo imagery that is used to build a DEM with a 15-m grid, enabling elevations to be determined for buildups along the shoreline and paleoshorelines.

Lago Strobel is a large (97.6 km²) isolated water body situated within a Miocene alkaline basalt plateau with little riverine flow into or out of the lake. Carbonate buildups are situated around the entire perimeter of the lake (47.4 km); however, their distributions are not homogeneous and can be characterized into distinct physical morphologies. The first occurrence of calcium carbonate is at approximately 22.5 m above the present-day lake level and continues down slope into the shallow littoral sections of the lake. Such shoreline deposits have an average width of 141 m and cover a total of 6.7 km². Carbonate deposits most commonly form a bulbous morphology that accretes into columnar structures. Thin coatings on basalt boulders are less common and are found in isolation from other thicker deposits. Bulbous buildups commonly coalesce to form pustular sheets that extend 10 – 500 m. These larger buildups accrete into the lake to form large promontories and small islands.

These analyses when combined with ground truthing can provide valuable insights into the controls governing the occurrences of carbonate precipitation in alkaline lakes. Lago Strobel has a substantial carbonate deposit rimming its shore that varies in thickness, width, and morphology. Coalescing domal buildups dominate much of the shoreline and are volumetrically the most significant carbonate deposit. New

perspectives on alkaline lake systems, such as Lago Strobel, can help gain a better understanding of climate history, regional tectonics, and in better characterizing subsurface hydrocarbon reservoirs, particularly those in pre-salt regions along the South Atlantic conjugate margins.

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Della Porta, G., and F. Barilaro, Non-Marine Carbonate Precipitates: A Review Based on Recent and Ancient Case Studies: Search and Discovery Article #30217 (2011). Website accessed August 27, 2015, http://www.searchanddiscovery.com/documents/2012/30217dellaporta/ndx_dellaporta.pdfDella.

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Gilli, A., F.S. Anselmetti, D. Ariztegui, P. Bradbury, K.R. Kelts, V. Markgraf, and J.A. McKenzie, 2001, Tracking abrupt climate change in the Southern Hemisphere: a seismic stratigraphic study of Lago Cardiel, Argentina (49°S): Terra Nova, v. 13, p. 443-448.

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Wright, V.P., 2012, Lacustrine carbonates in rift settings: the interaction of volcanic and microbial processes on carbonate deposition, *in* J. Garland, J.E. Neilson, S.E. Laubach, and K.J. Whidden, editors, Advances of Carbonate Exploration and Reservoir Analysis: Geological Society, London, special Publications, 370, p. 39-47.

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Satellite Imagery in Lacustrine Systems

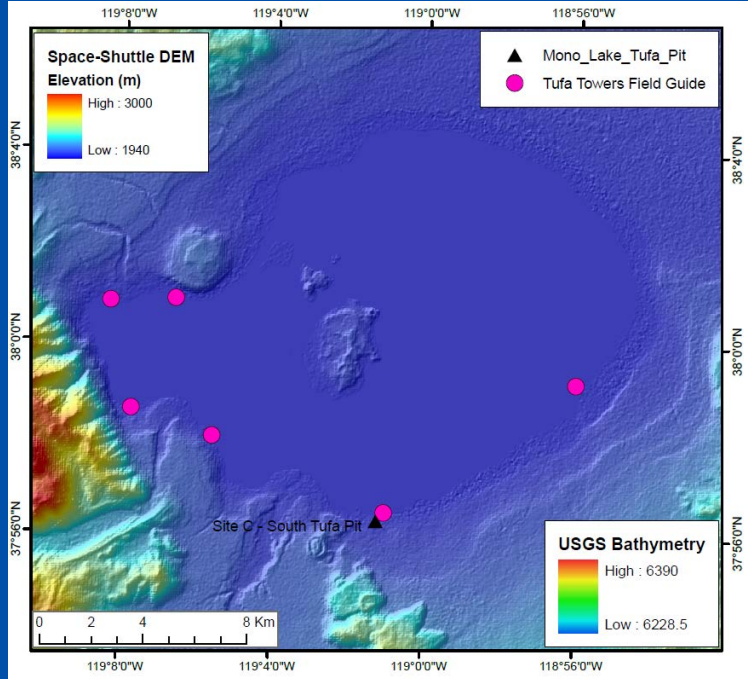
Spatial & Temporal Changes of Carbonate Deposition



- 1) Digital Elevation Models (DEM), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), and Quickbird Satellite imagery are powerful analytical tools with which to study modern lacustrine systems.
- 2) Satellite imagery enables a better understanding of spatial and temporal distribution patterns of carbonate occurrences within these systems.
- 3) Temporal variations in modern lacustrine systems can be determined through the scrutiny of Quickbird data sets from different vintages.
- 4) Quickbird data acquisitions over Lago Strobel in May 2005 and December 2012, indicate substantial carbonate deposition and/or exposure associated with a 2-3 m drop in lake level.

Carbonate Occurrences in Lakes

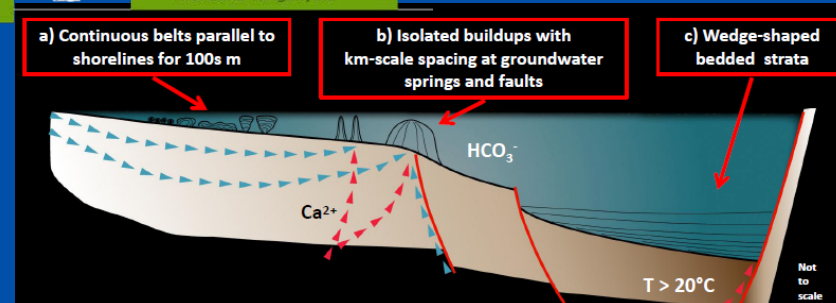
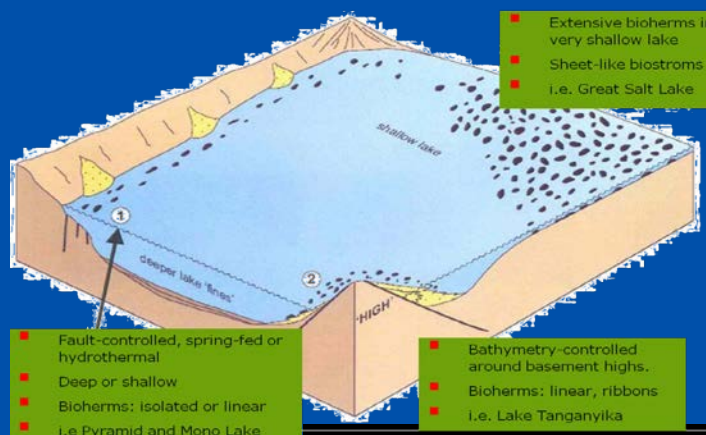
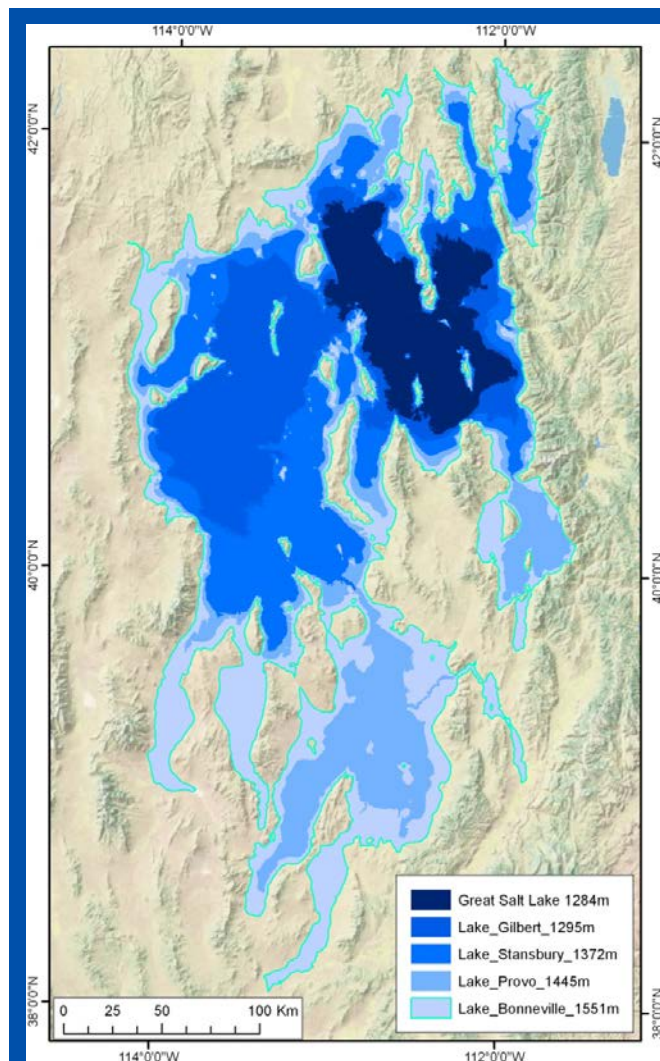
Mono Lake



- 1) Localized, fault controlled precipitation of calcium carbonate.
- 2) Carbonate deposits are volumetrically low on a regional scale.
- 3) Deposits record the paleolake levels, with some uncertainty around buildup height lost to erosion.

Carbonate Occurrences and Lake Level Variations

Great Salt Lake (and Lake Bonneville)



Wright (2011, 2012), Della Porta et al (2011), and Della Porta and Barilaro (2011) discuss models for non-marine carbonates; two of their figures summarize the spectrum of deposits that various analogs illustrate.

Lago Strobel, Santa Cruz, Argentina

Large scale carbonate accumulation along shoreline

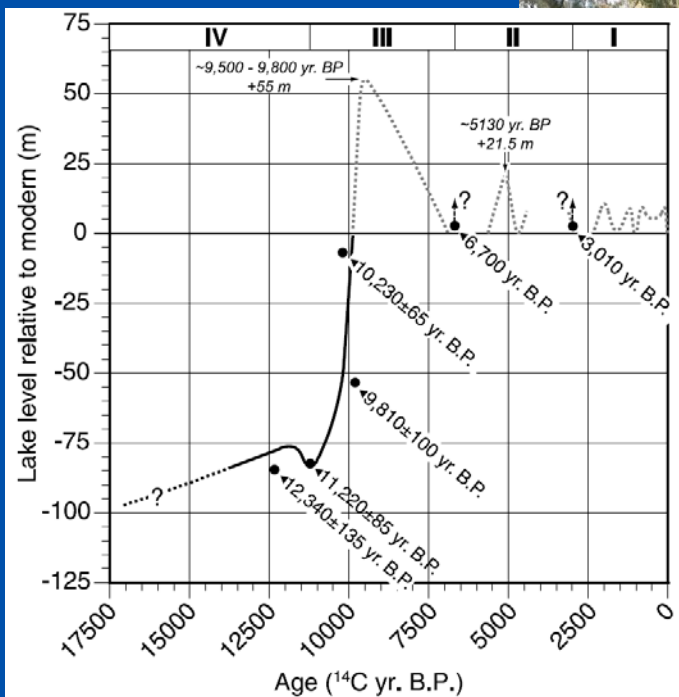


- 1) Closed hydrologic system, **97.6 km²** in area with **47.4 km** of shoreline.
- 2) Situated within a Miocene alkaline basalt plateau collapse feature.
- 3) **Semi-arid** climatic regime, BSk Köppen Climate Classification.
- 4) Hydrologic system and lake level history are poorly understood.
- 5) Highly nutrient lake waters provide exceptional rainbow trout habitat, where productivity is abnormally high.



Regional Lake Level History

Analogues for Lago Strobel?

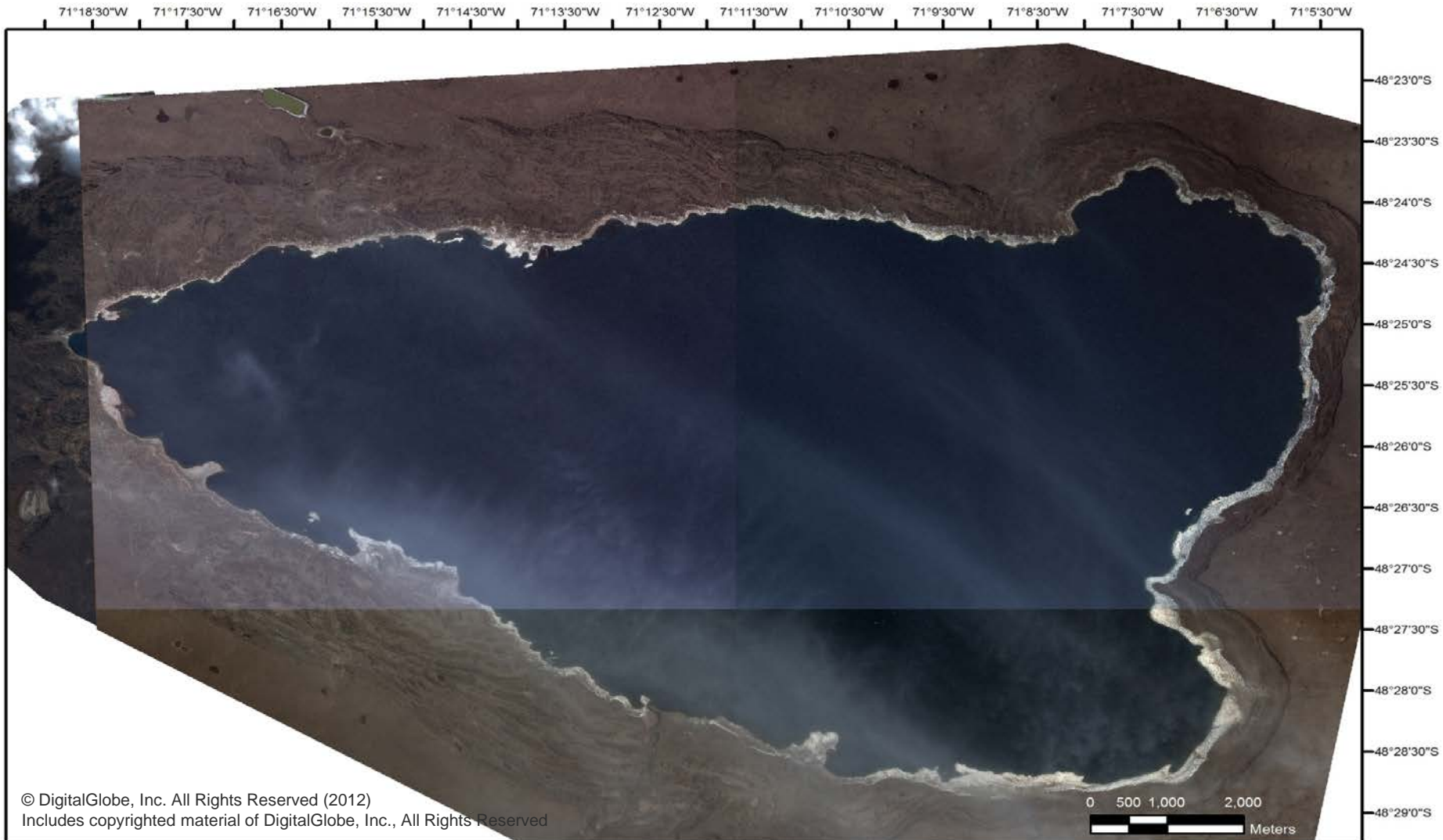


Gilli et al., 2001, *Terra Nova*, © Blackwell Science Ltd

- Lago Cardiel located 50 km to the south of Lago Strobel.
- Interpreted lake-level history of Cardiel based on seismic and lithology data.
- Does Lago Strobel follow the same trend? Initial age of carbonate precipitation?

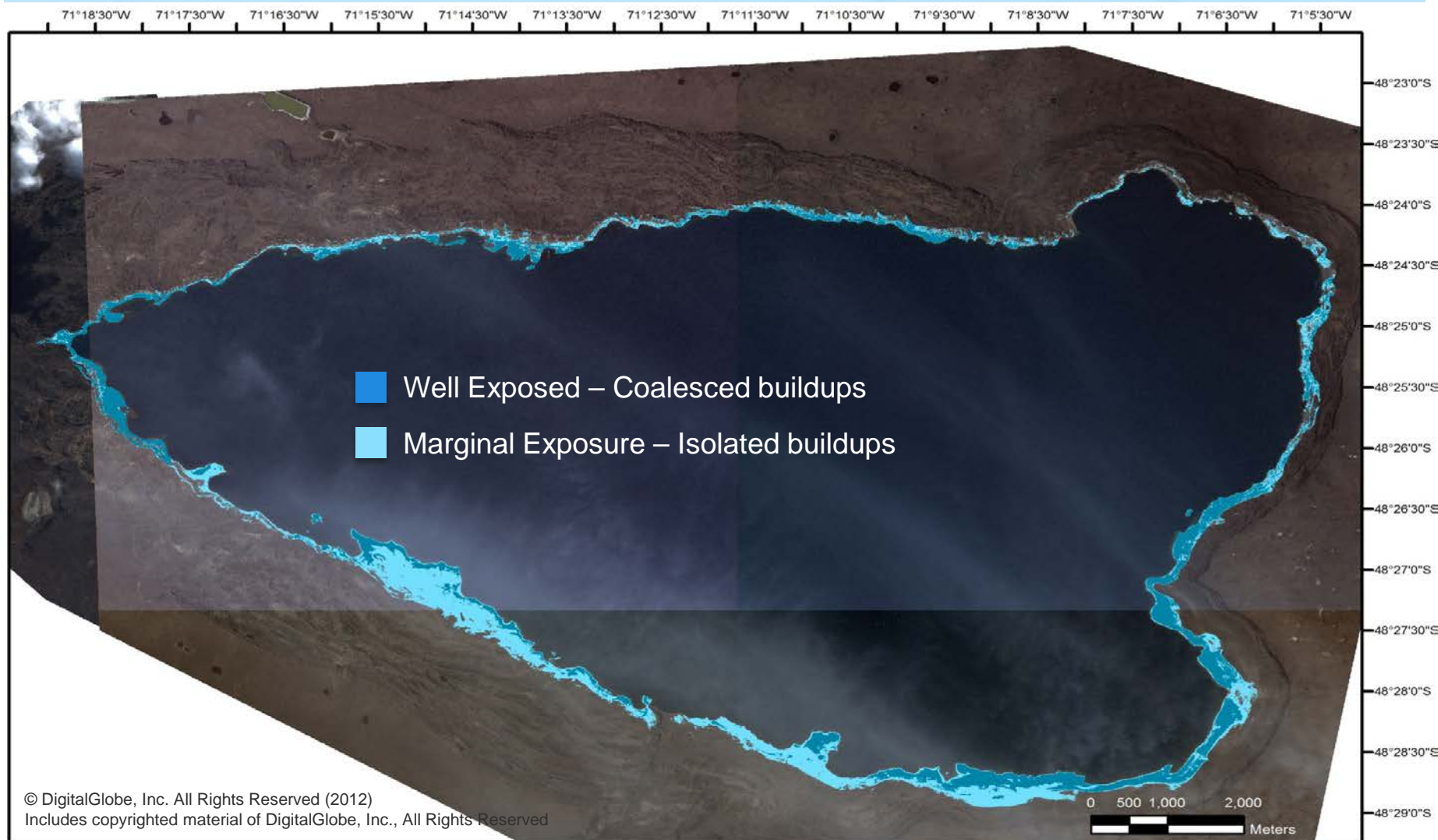
Lago Strobel – Quickbird Mosaic

December 2012



Lago Strobel – Spectral Analyses

December 2012 – Carbonate Exposure Index



Buildup Morphologies

Coalesced Buildups



© Google Earth – Panoramio Image
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Buildup Morphologies

Isolated Domal Buildups



Carbonate Buildup Occurrences and Distribution

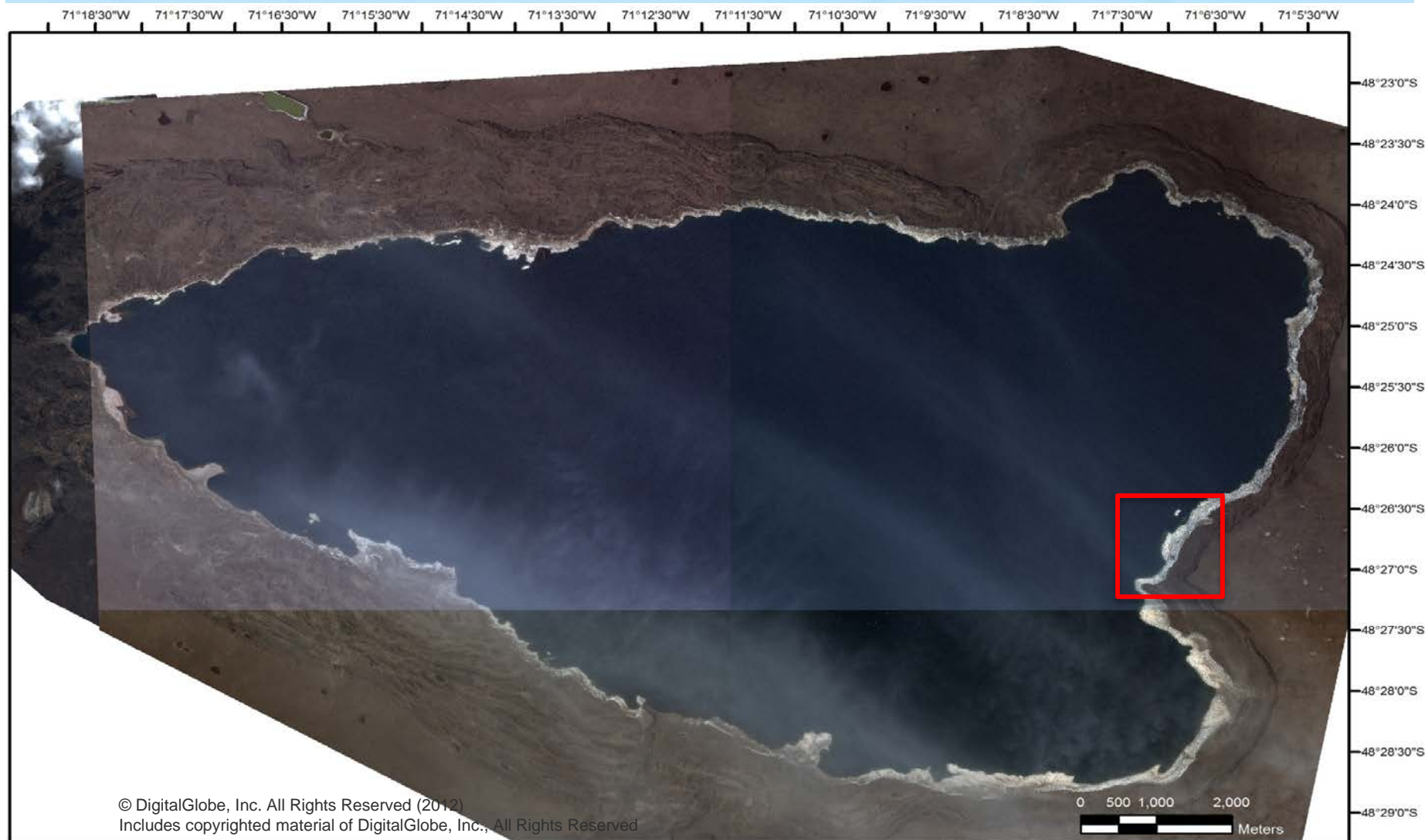
Lago Strobel



- 1) Carbonate shoreline width = highly variable but **141 m average**, ranges from 0 m to 400 m, most common range is 100 m to 175 m.
- 2) Lengths along shoreline – dominantly 1 km to several km's of continuous carbonate deposits.
- 3) Dominantly located on promontories and other high energy settings, less common or absent in the many small embayments along the shoreline.
- 4) Initial carbonate occurrence approximately 22.5 m above present day lake level (needs ground truthing to make precise measurement).
- 5) Carbonate deposits cover **6.7 km²** of the shoreline that is presently subaerially exposed.
- 6) 5 different buildup morphologies.

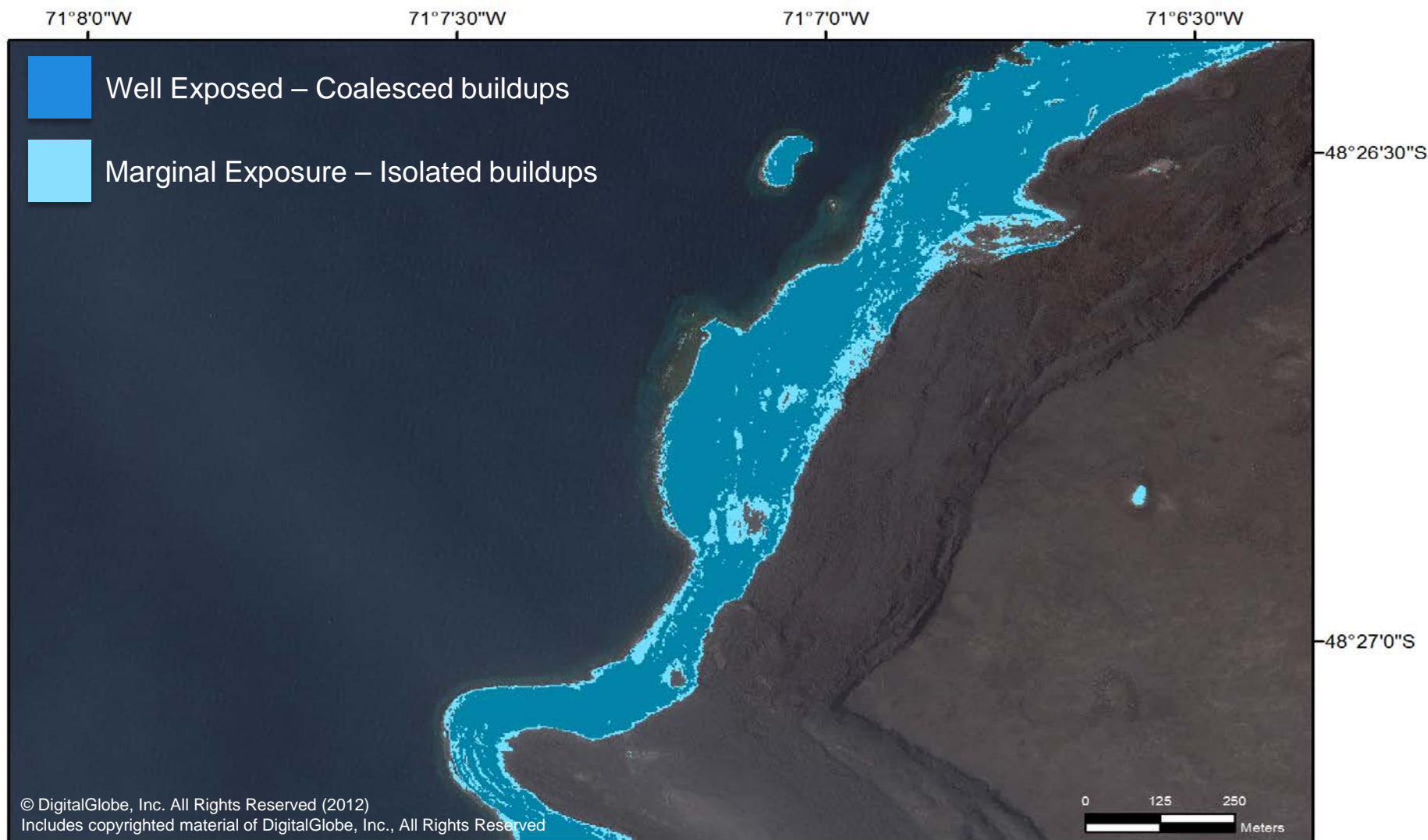
Lago Strobel – Eastern Shoreline Detail

Quickbird December 2012



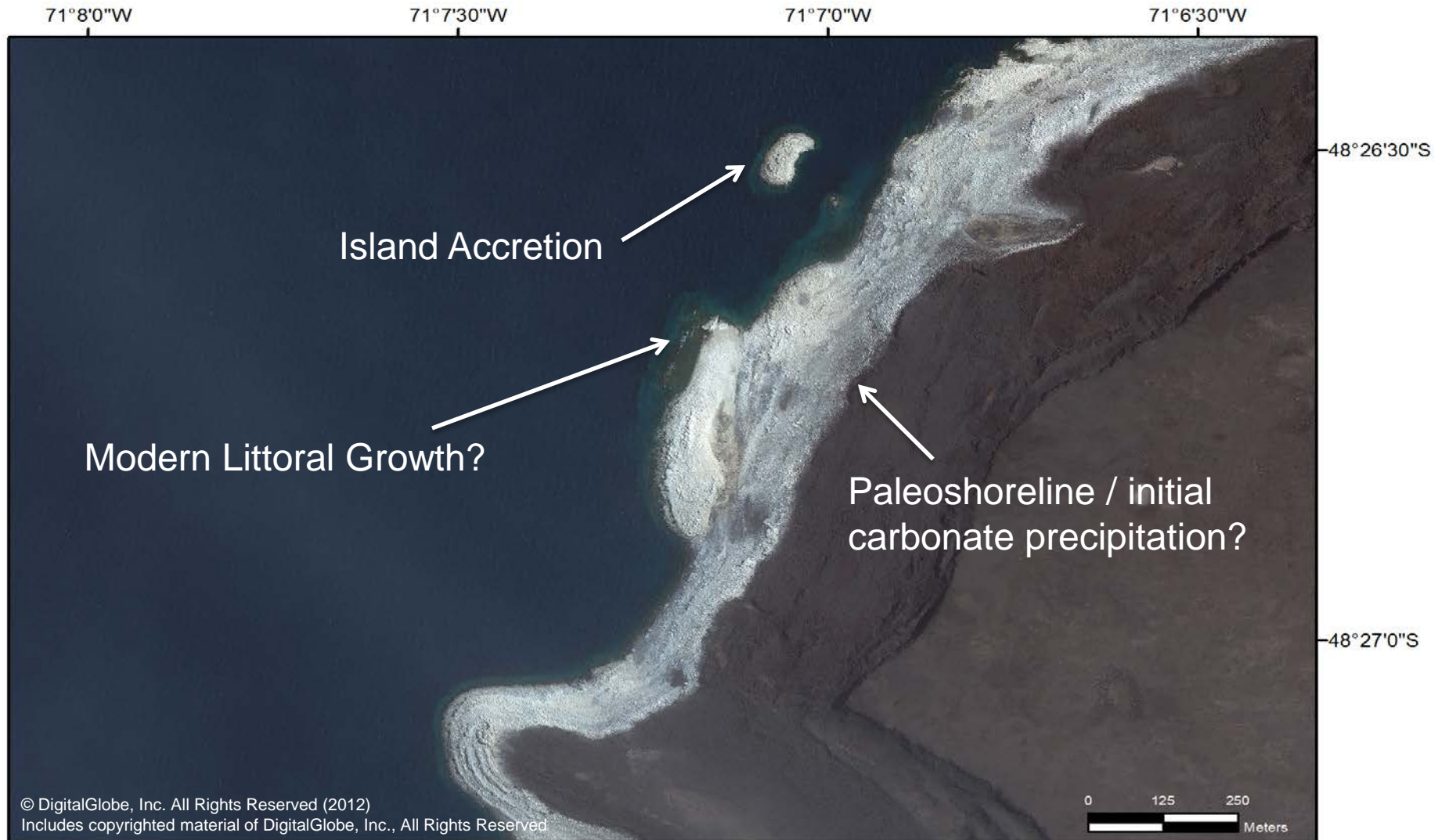
Lago Strobel – Spectral Analyses

Quickbird December 2012



Lago Strobel – Shoreline Detail

Quickbird December 2012

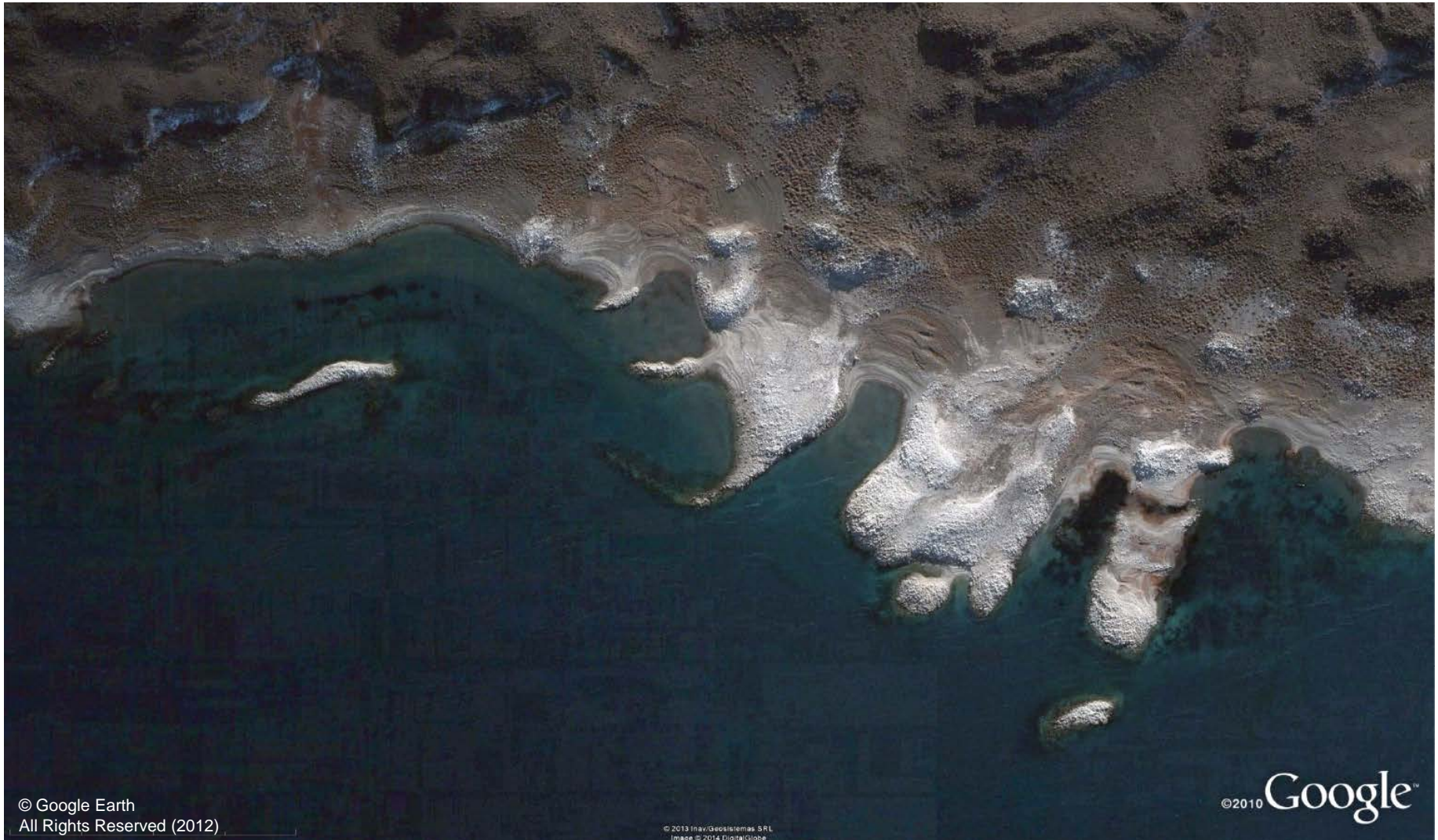


Lake Level Variations and Insights into Carbonate Productivity



Lago Strobel – Shoreline Detail

Acquisition Date **May 2005**



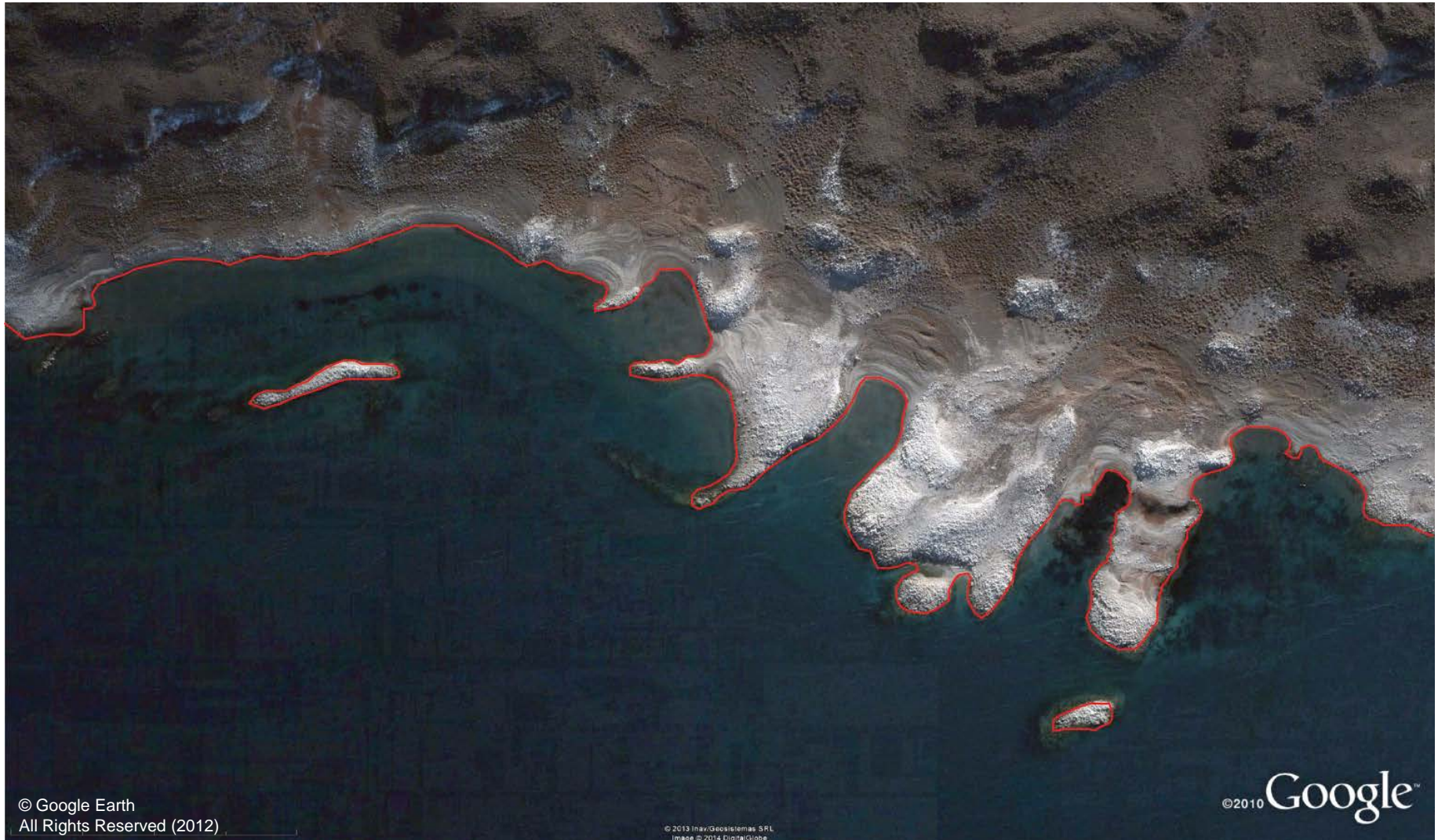
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Lago Strobel – Shoreline Detail

Acquisition Date **May 2005**



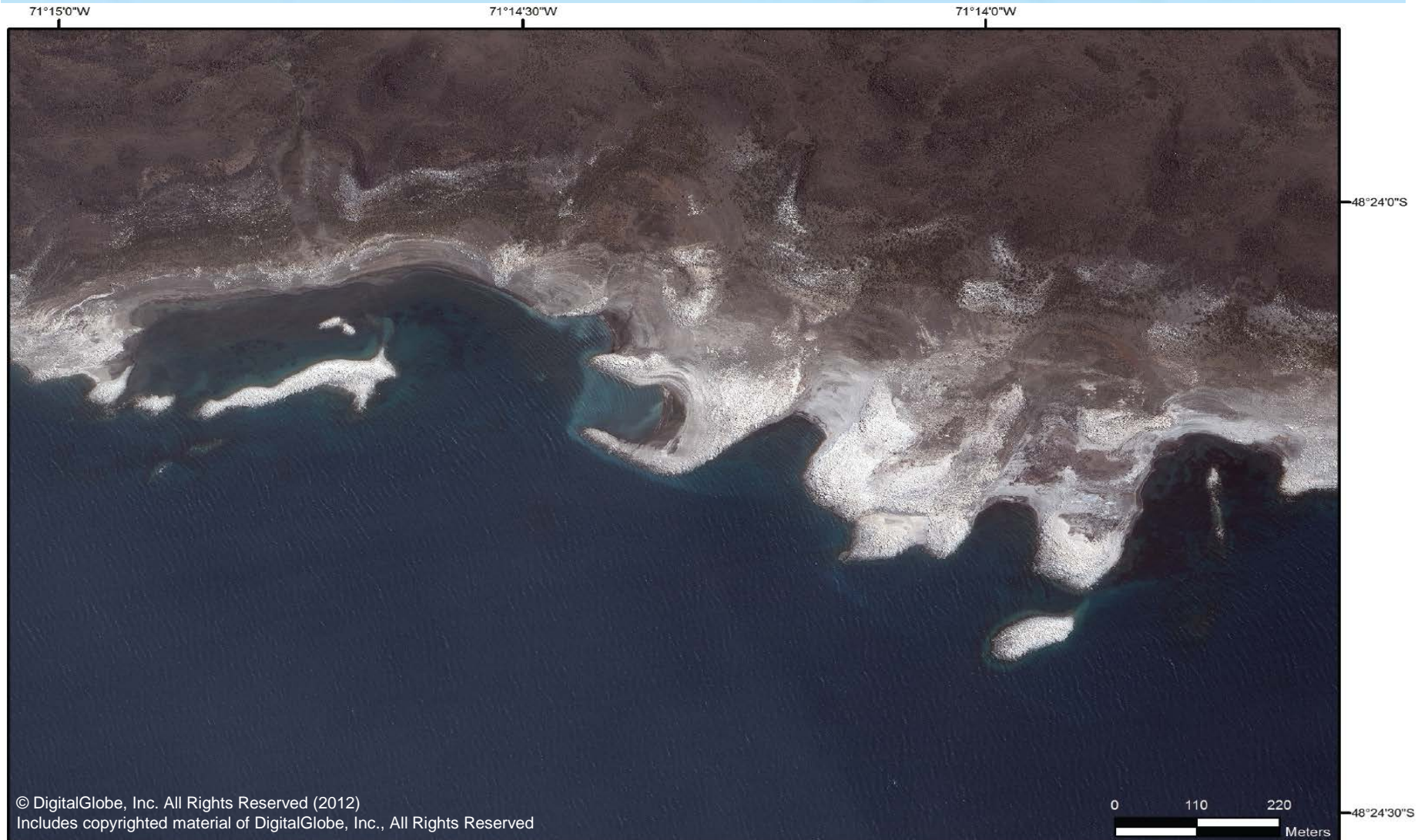
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Lago Strobel – Shoreline Detail

Acquisition Date **December 2012**



Lago Strobel – Shoreline Detail

Acquisition Date **December 2012**



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Synthesis and Concluding Remarks



- 1) Satellite imagery can be useful for recognizing carbonate distribution patterns along lake shorelines and to determine how these systems change during lake level change.
- 2) Spectral analyses can differentiate carbonate from non-carbonate along shorelines to easily calculate areas of carbonate occurrences and distribution patterns.
- 3) Lago Strobel is a closed lake system that has significant carbonate precipitation along its shoreline. Unlike most other carbonate lakes these deposits continue around the entire lake perimeter. What are the precipitation mechanisms?
- 4) In the past 7.5 years lake level has fallen ~ 2-3 m and the carbonate system has changed. Substantial carbonate deposition has occurred in that time; formation of islands, aggrading margins, promontory formation, and also transitions into non-carbonate precipitation.