Climate fluctuations did exert a dominant control on the style of sedimentation in the South Caspian Basin, through their direct impact both on lake levels and sediment supply. Spectral analyses of gamma logs reveal systematic patterns in sand/mud ratios. These patterns also reveal a set of nested cycles that correspond to the relative durations of Milankovitch precession cycles (~20 ky), short eccentricity cycles (~100 ky) and long eccentricity cycles (~400 ky). The Kirmaky Suite reveals a strong signal of sandstone-shale successions ranging in thickness between 12 and 22 meters, attributed to the ~20 ky precession cycles. Search for longer period cycles was limited to one subsurface gamma log of the Balakhany Suite. The associated spectrum revealed peaks in the 55 to 80 m range and 210 to 300 m range, attributed to short (~ 100 ky) and long (~ 400 ky) eccentricity cycles.

The observed sediments were deposited in fluvial, lake-margin playa, shoreline and open lake depositional systems. The sequence boundary is an exposure surface within mudstones. The palynology of mudstones documents an associated dry climate. Above the sequence boundary lays a forestepping succession of terminal splay sandstones and mudstones suggesting slowly rising lake level; the palynomorphs indicate corresponding increase in humidity. Above this there is a stack of braided stream deposits that generally represent the dominant sandstone interval of the entire sequence. This is interpreted as a lowstand systems tract, which is abruptly truncated by a lacustrine flooding surface, which in turn is capped by a backstepping succession of more terminal splay deposits. The palynomorphs indicate that the climate remained humid during deposition of this transgressive systems tract.
Origin and Expression of Pliocene Climate Cycles in the Caspian Basin

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by

Dag Nummedal
Colorado Energy Research Institute
Colorado School of Mines
Golden, CO 80401
Caspian Sea

Volga Delta

Baku
Seismically Defined Sequences – in Depth

Abreu and Nummedal, 2007
Seismically Defined Sequences – in Time

$^{40}\text{Ar}/^{39}\text{Ar}$ ages from 5 ash beds

Abreu and Nummedal, 2007
Geologic Map of the Surroundings of Baku

Note Kirmaky Valley
Kirmaky Valley
Outcrop Gamma Log at Kirmaky Valley
<table>
<thead>
<tr>
<th>MESSINIAN</th>
<th>Ar$^{39}$/Ar$^{40}$</th>
<th>COSMOPOLITAN DINOFLAGELLATES</th>
<th>SUITES</th>
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<tbody>
<tr>
<td>5.32 Ma</td>
<td>2.6 Ma</td>
<td>Batiacasphera sphaerica</td>
<td>Akchagylian</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lejeunecysta globosa</td>
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<tr>
<td></td>
<td></td>
<td>Selenopemphix brevispinosa</td>
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</tr>
<tr>
<td></td>
<td>3.34 Ma</td>
<td>Cardosphaeridium minimum</td>
<td>Surakhany</td>
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<td></td>
<td></td>
<td>Labyrinthodinium truncatum</td>
<td>Sabunchi</td>
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<td></td>
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<td>Systematophora placacantha</td>
<td>Balakhany</td>
</tr>
<tr>
<td></td>
<td>5.75-5.93 Ma</td>
<td></td>
<td>Pereriva</td>
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<tr>
<td></td>
<td>5.91 Ma</td>
<td></td>
<td>Kirmaku suite</td>
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<td></td>
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<td>6.20 Ma</td>
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<td>5.75-5.93 Ma</td>
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<td>Pontian</td>
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</tbody>
</table>
Insolation Index from 6 to 4 Ma

Berger and Loutre, 1992
Cycle Tuning, Kirmaky Suite

Kirmaku Valley Gamma Log correlated to Precession Index
BALAKHANY GAMMA LOG CORRELATED TO PRECESSION INDEX

Precession Index 4.0-5.5 Ma

Age, Ma

GCA-2.5 m moving average

13 cycles Pereriva

Bal.X 80m(100ky)

Bal.VII 320m(400ky)

Bal.VI

Depth, m
Kirmaky Suite Outcrop
FINE-GRAINED INTERVAL
KIRMAKY SUITE

SANDSTONE COMPLEX

155

150

145

VERY FINE SAND
MUD
RIZOLITHS

SANDSTONE COMPLEX
Cemented Rhizomes in Kirmaky Suite
HIGH-FREQUENCY CLIMATIC/SEDIMENTOLOGIC CYCLE, KIRMAKY SUITE

DRY WET

LAKE LEVEL FALL
MAXIMUM LAKE LEVEL
LAKE LEVEL RISE

DEEPEST LACUSTRINE SEDIMENTATION
UPWARD-DEEPENING LACUSTRINE SEDIMENTATION
INUNDATION OF SANDSTONE
FLOOD DEPOSITS AGGRADE

SUBAERIAL EXPOSURE
UPWARD-SHALLOWING LACUSTRINE SEDIMENTATION
DEEPEST LACUSTRINE SEDIMENTATION

LAKE LEVEL RISE
MAXIMUM LAKE LEVEL
LAKE LEVEL FALL
Lake Level Cycles – Pereriva Suite

IDEAL SMALL SEQUENCE LOG

INTERPRETATION

Channel base
Delta front (forestep)
Subaerial exposure with Intermittent flooding
Delta front (backstep)
Transgressive surface
Channel base

LAKE LEVEL CURVE

High
Low

10 m

BRAIDED FLUVIAL

Channel base
Sequence Boundary in the Pereriva Suite

Shale clasts containing Caspibrackish fauna
The Many Pereriva Sequences

PRECESSION INDEX 4.85-5.25 Ma

PRECESSION

Age, Ma

GAMMA, CPS

Depth, m

CGA-2 PERERIVA GAMMA
Conclusions

The latest Miocene and Pliocene clastic succession in the SW Caspian Sea contains a nearly complete record of 20 ky to 400 ky Milankovitch climate cycles.

Sediments, erosion surfaces, pollen, and ostracods all reflect these repeated cycles of climate and water depth.

The 20 ky sequence boundaries are expressed as exposure surfaces in mudstones (Kirmaky Suite), and lags of lake-derived mudstone clasts with sandstones (Pereriva Suite).

The palynomorphs indicate that the climate was humid during deposition of the mostly sandy lowstand and transgressive systems tracts. HST and FSST are muddy, thin and formed during dry climate phases.
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References
