



Exploring the Limits of Life in the Highest Lakes on Earth

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Mars Underwater Project (NAI)

- **What?**

- Explore high-altitude lakes ($\geq 6,000$ m \sim 20,000 ft) to document life survival strategies in extreme conditions.
- Astrobiology, planetary geology, physiology/medecine, education & public outreach

- **Why?**

- Best Terrestrial analogs to ancient Martian lakes;
- Understand the limits of life (extremophiles) on Earth and apply to planetary exploration;
- Prepare NASA missions for the search for life on Mars;
- Improve public health (better understanding of heart and lung diseases, monitoring of physiological response in extreme environment with application to space)

Science Rationale

- Was Mars Habitable? Yes! (MER mission)
- Did life ever appear on Mars? What is the biological potential of analogs to ancient Martian lakes

Climbing high on Earth equals is like going back in time on Mars...



Andes and Himalayas

Licancabur Volcano

Chile/Bolivia

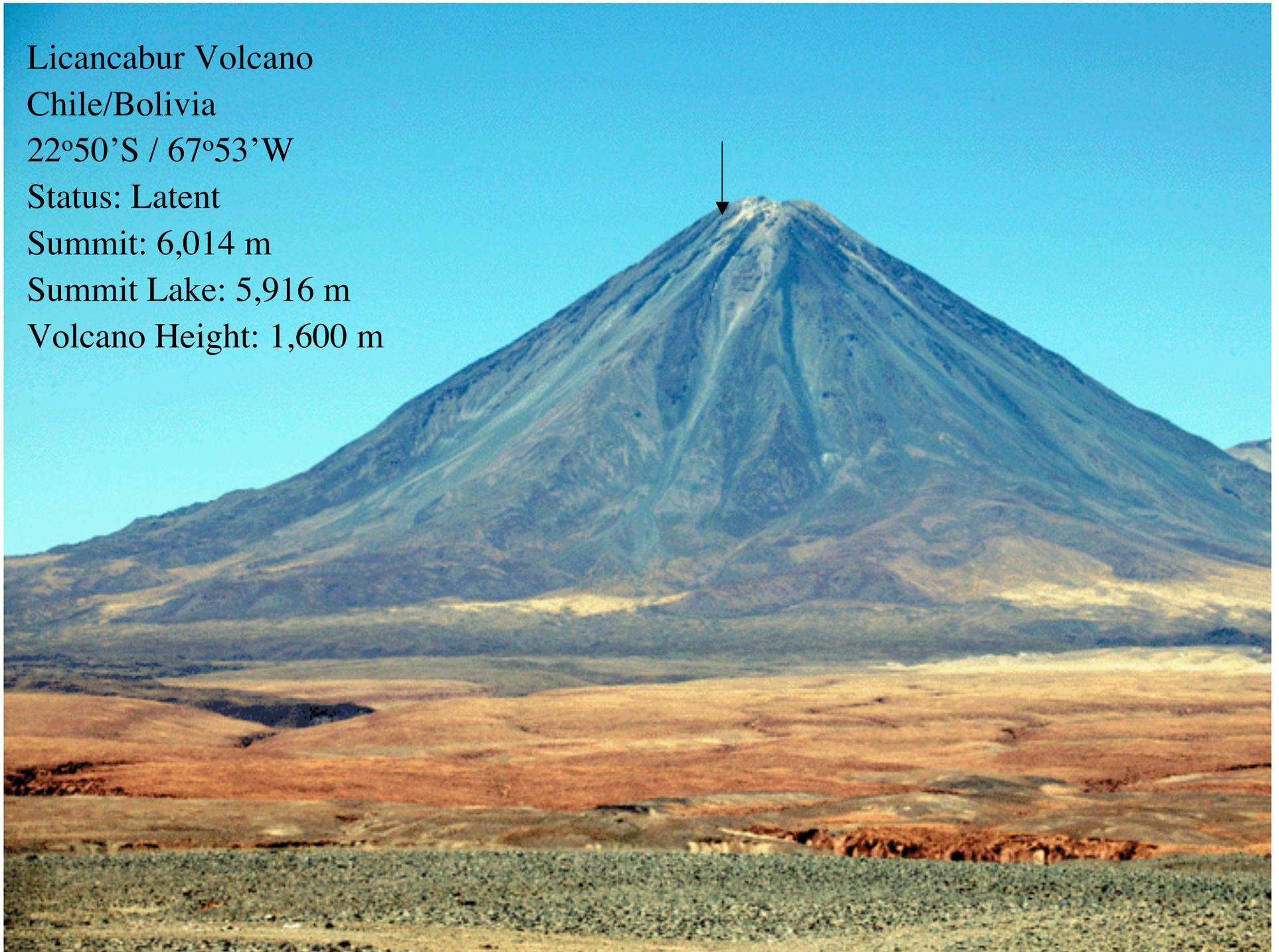
22°50'S / 67°53'W

Status: Latent

Summit: 6,014 m

Summit Lake: 5,916 m

Volcano Height: 1,600 m



Environment and Analogy

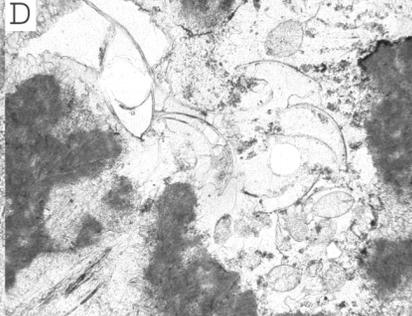
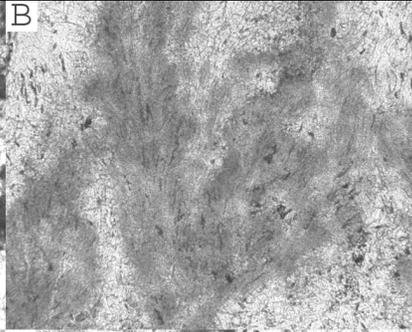
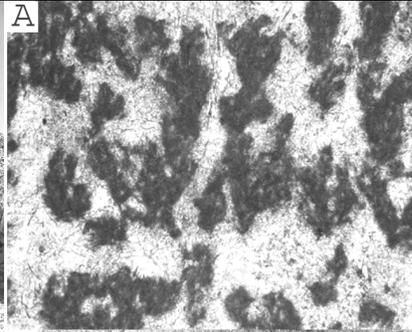
Physical Parameters	Laguna Blanca and Verde	Licancabur Summit Lake	Mars 3.5 Gy¹
Atmospheric Pressure (mb)	550-600	480	500
Temperature range (°C)	-30 to +12	-40 to +5	-50 to +27
UV Radiation (% sea level)	140	~150	Present Earth-Like ²
Aridity (% Relative Humidity, RH)	9-25	10-35	Low
Seasonal Ice Cover	Yes	Yes	Yes
Sed. in Volcanic Environment	Yes	Yes	Yes
Hydrothermal Input	Yes	Yes	Yes
Precipitation (mm·y ⁻¹) from snow	Low (< 200)	Low (< 200)	Low
Elevation (m)	4,435	Sum: 6,014 / L: 5,916	N/A
Partial Pressure O ₂ (% sea level)	58	48	Unknown
Life	Abundant	Abundant	Unknown

Shallow lakes: strong evaporation -- UV impact in thin water column





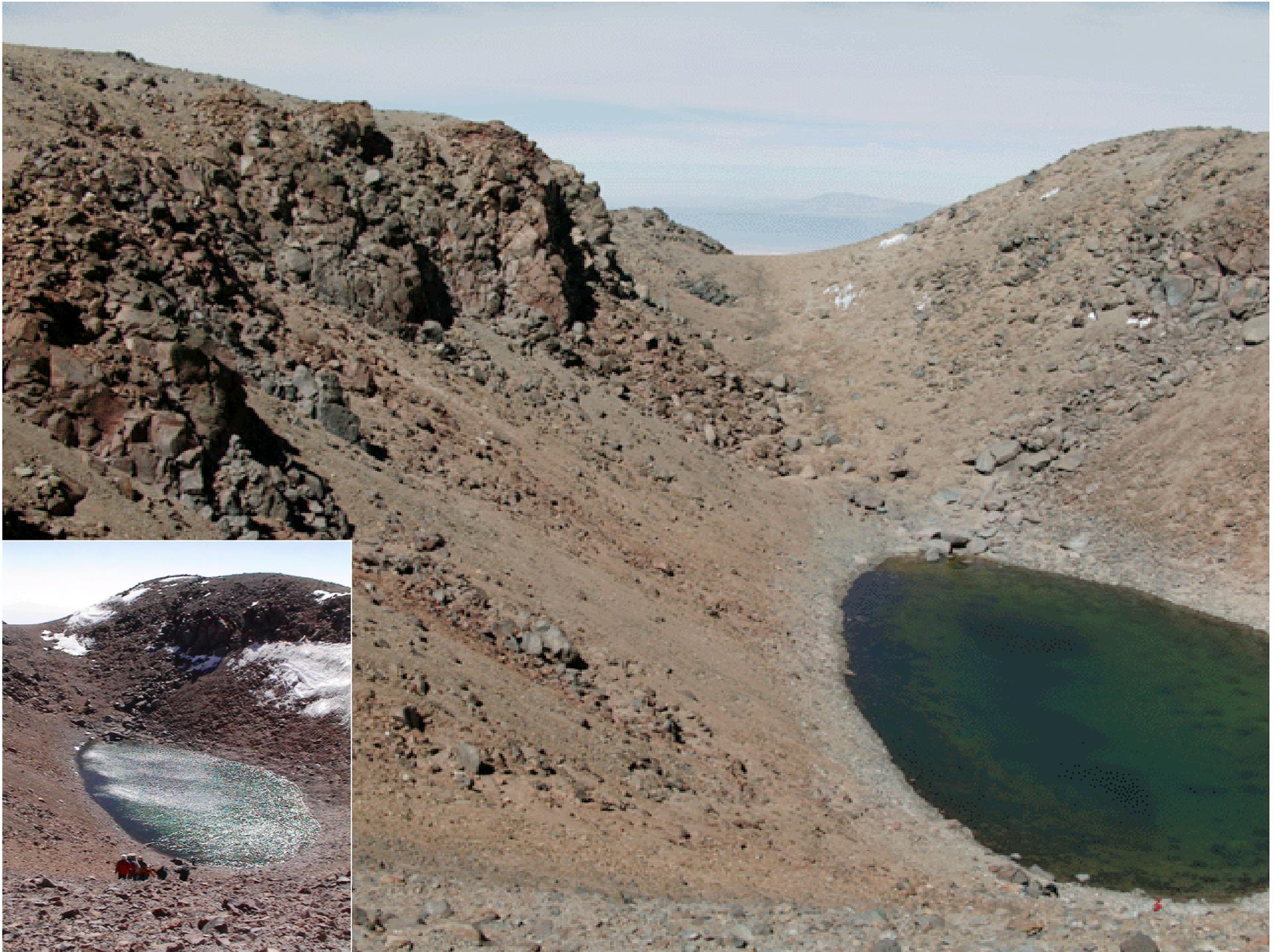


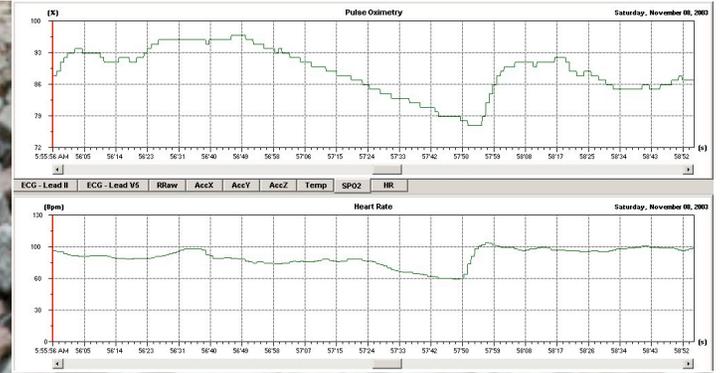




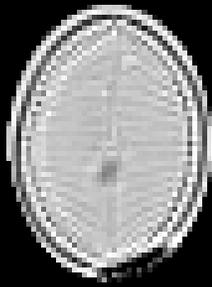








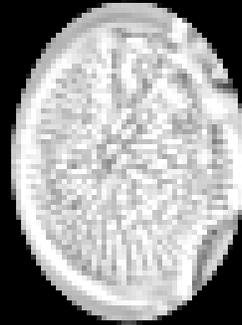




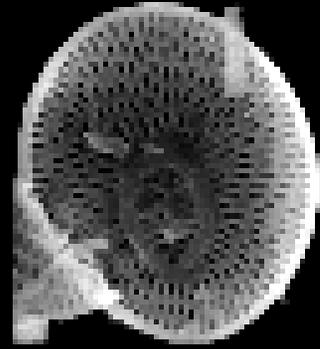
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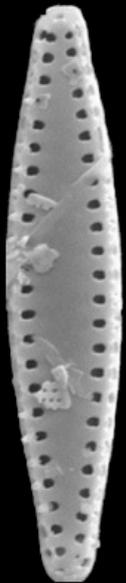
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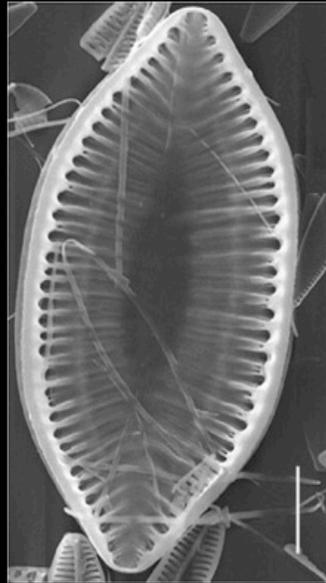
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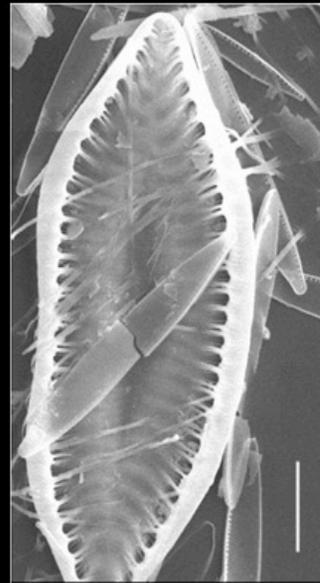
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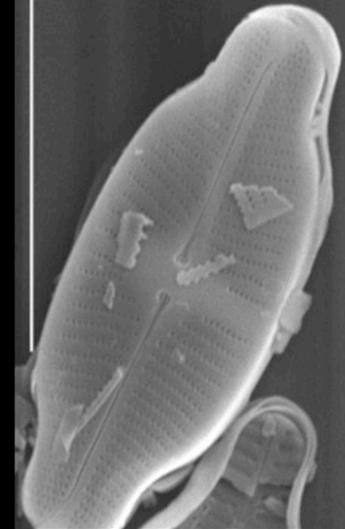
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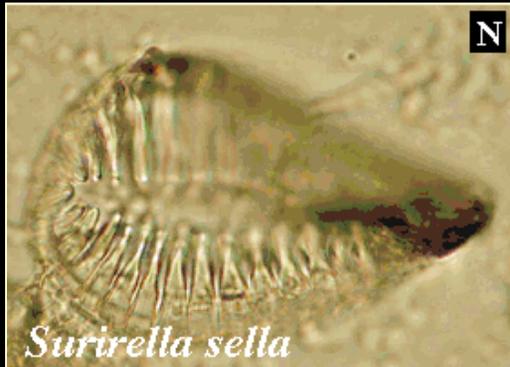
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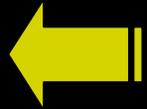
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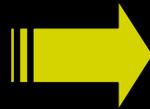
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The team found high numbers of live *Surirella Sella*... This species was described mostly from fossil samples, rarely mentioned alive. It is abundant in both lagunas.

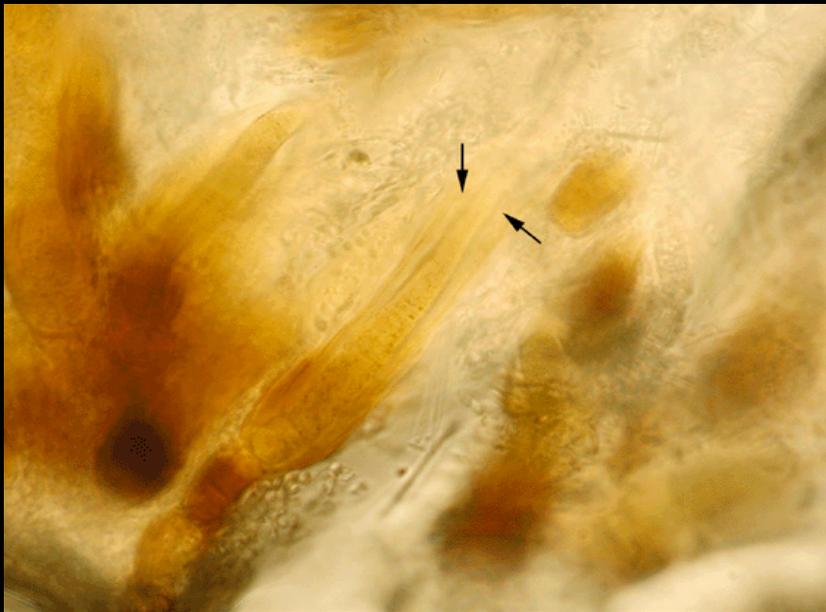


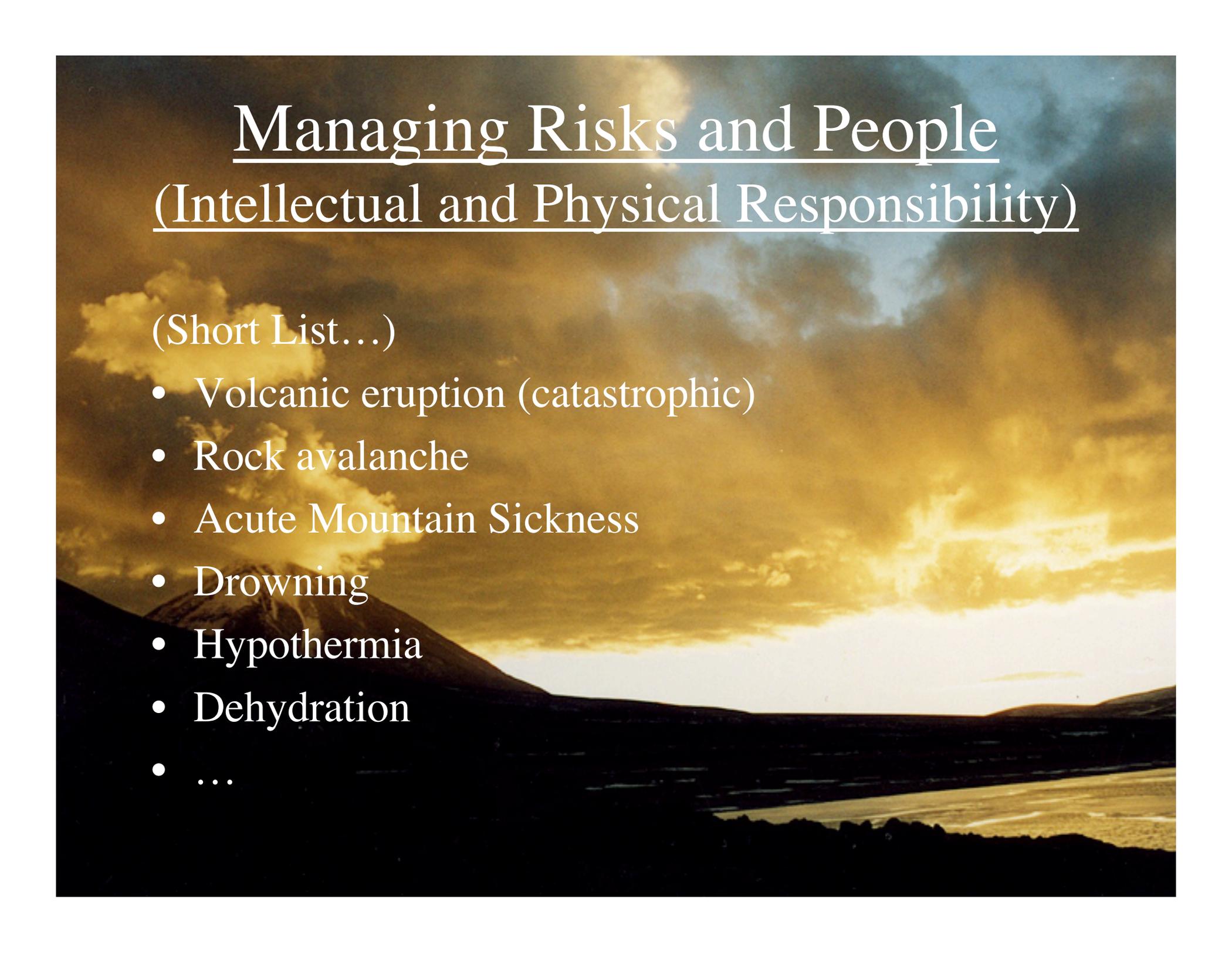
L: *Surirella Sella* (LM)
living cell with
chloroplast found in the
central region (LV and
LB). Scale: 10µm.



M: *Cyclotella baltica*.
First record of the
species outside the
Baltic Sea and in a lake.
Scale: 5 µm.







Managing Risks and People (Intellectual and Physical Responsibility)

(Short List...)

- Volcanic eruption (catastrophic)
- Rock avalanche
- Acute Mountain Sickness
- Drowning
- Hypothermia
- Dehydration
- ...

Managing Risks and People (Intellectual and Physical Responsibility)

- Risk taking is inherent to exploration and necessary to discovery. For species, it is the essence of survival and progress (payoff);
- Risk is mitigated as much as possible (training, safety advice).
- It is the PI's personal decision (project), a management decision (reviewers) and a group responsibility field team);
- In the field, it is the ultimate responsibility of the PI to deal with the situations according to personal and group situations (managing different people).

Managing Risks and People (Intellectual and Physical Responsibility)

