



NSF safety workshop 2009



Chajnantor plateau – 16500ft



April 2009 - J.Lassalle -





ALMA

- ❖ The Atacama Large Millimeter, Sub Millimeter Array (ALMA), one of the largest ground-based astronomy projects of the next decade, is a major new facility for world astronomy and the principal objective is the installations of the 66 antennas.
- ❖ ALMA is located on the high-altitude Llano de Chajnantor (16500ft), east of the village of San Pedro de Atacama in Chile.
- ❖ The ALMA project is a partnership between Europe, North America and Japan in Cooperation with the Republic of Chile.

OSF/TF





Introduction

Relevant aspects of high altitude physical activity include:

- ✓ oxygen, extreme temperatures, solar radiation, dry air, and psychological reactions to these items.
- ✓ The most important challenge to the well being of workers performing work at the ALMA High Site is the relative lack of oxygen.
- ✓ To some extent, all workers will suffer physiological and metabolic changes that diminish the capability to perform both physically and mentally.
- ✓ These physiological & metabolic changes also contribute to risk of severe high altitude related diseases. Considering the nature of construction, this increases the chance of having accidents.
- ✓ Trauma at altitude is difficult to manage due to the environmental challenges that high altitude offers for medical rescue.



ALMA Safety Requirements

Medical requirements required over OSF site (~9500ft):

- ALMA staff, Executives staff & Contractors:
 - Yearly HAME (High Alt. Med. Exam)
ALMA safety receive certificate to follow up and inform expiration date.
 - CWG (Chajnantor Members) adhere but keep responsible.

- Visitors, transporters (besides escorted)
 - High Alt risk Information prior travelling (Public Rel – Procurement Officers..)
2 hours max at the high site
 - OSF paramedic screening
 - Waiver and release



ALMA Safety Requirements

Safety trainings for high site workers:

- General safety training
- High altitude risk information
- First aid and AED use (Automatic External Defibrillator)
- Use of O2 and oxygen meter

Safety trainings for high site visitors & transporters:

- Basic safety training
- High Alt risk Information
- Use of O2 and oxygen meter
- Escort

Oxygen Use at Chajnantor



Aerosol O₂



2 types oxymeters
NONINO (black)
and HEAL FORCE



O₂ bottles/ regulator

415 L Type D
248 L Type C
815 mL Can



MEDICATIONS

- No preventive medication is provided by ALMA paramedics to assist in altitude issues.
- The ALMA Safety Office and paramedics follow the ALMA medical protocol prepared and approved by expert physicians.
- The ALMA paramedic is connected to SPA/Dr
- Employees follow the recommended prescription as established by their physician.



OSF CLINIC EXAM PROTOCOL

The frequency of the check-up at the OSF is based on the following:

- Every affected person going above 9500ft for the first time.
- Every person that visits the site above 9500ft less than monthly.
- Any individual that feels unwell or has a desire to be checked.



RECOMMENDATIONS FOR ALTITUDE

Before Ascending:

- Spend one night at approximately ~ 9000ft (e.g. Calama, St Pedro de Atacama or OSF) before ascending in order to help acclimatize.
- Limit outside work hours at high site. Do not drive after long stay
- You must not be suffering from any acute respiratory infection.
- Eat a light breakfast and start early in the morning.
- ALMA provisions water to the staff.
- Drink abundant water (not less than 3 L daily) without carbonation, or gas, during the trip
- Natural fruit juice is recommended.
- Hydration should be self controlled by urine observation. Urine being nearly colorless indicates appropriate hydration.



Access requirements for Altitudes

- The access to the AOS is submitted to the staff's Supervisor authorization and safety team control (HAME- Training).
- AOS road access is controlled at the OSF Security control gate.
- Only listed people may access (+CWG)
- The guard checks cars and O2 equipment
- Radio communication required
- The AOS/TB guards control building access

AOS/TB



Chajnantor (16500ft)



© Stéphane Guisard



Sun radiation exposure policy

- Risk related to UV is part of safety training
- Safety provides hats and UV-blocking sunglasses.
- Sunscreen is available inside buildings.
- Wear a sunscreen that has a good Sun Protection Factor (SPF 50 recommended for long exposure)
- Reapply 2 or 3 times a day.
- Clothes should cover the arms, legs and neck



Recommendation at Altitudes

- Do not visit the site if you are already feeling unwell
- If you feel headache, dizziness, vomiting, and breathing difficulty, go to the AOS polyclinic or call for help
- Do not expose yourself unnecessarily to the cold.
- Do not perform strenuous exercise without O₂.
- Never sleep at a high altitude except for emergency (with ALMA Safety authorization).
- Special meals are prepared for high site workers



Oxygen Use at Chajnantor

- Oxygen bottles are provided for all work activities at the high site.
- An Oxygen meter is provided for all groups of workers or individuals in order to check the oxygen saturation.
- Supplemental oxygen is mandatory for drivers staying for long runs at the high site, e.g. antenna transporter.
- Supplemental oxygen is recommended when O₂ saturation is < 80%.
- Personal aerosol oxygen is provided to visitors.
- Inside the AOS/TB supplemental oxygen is generated, distributed, and maintained through a central system.



Chajnantor's First Aid Station

- 1 paramedic 12/24h – 7/7
- 1 ambulance
- 1 driver (handyman & first aid worker)



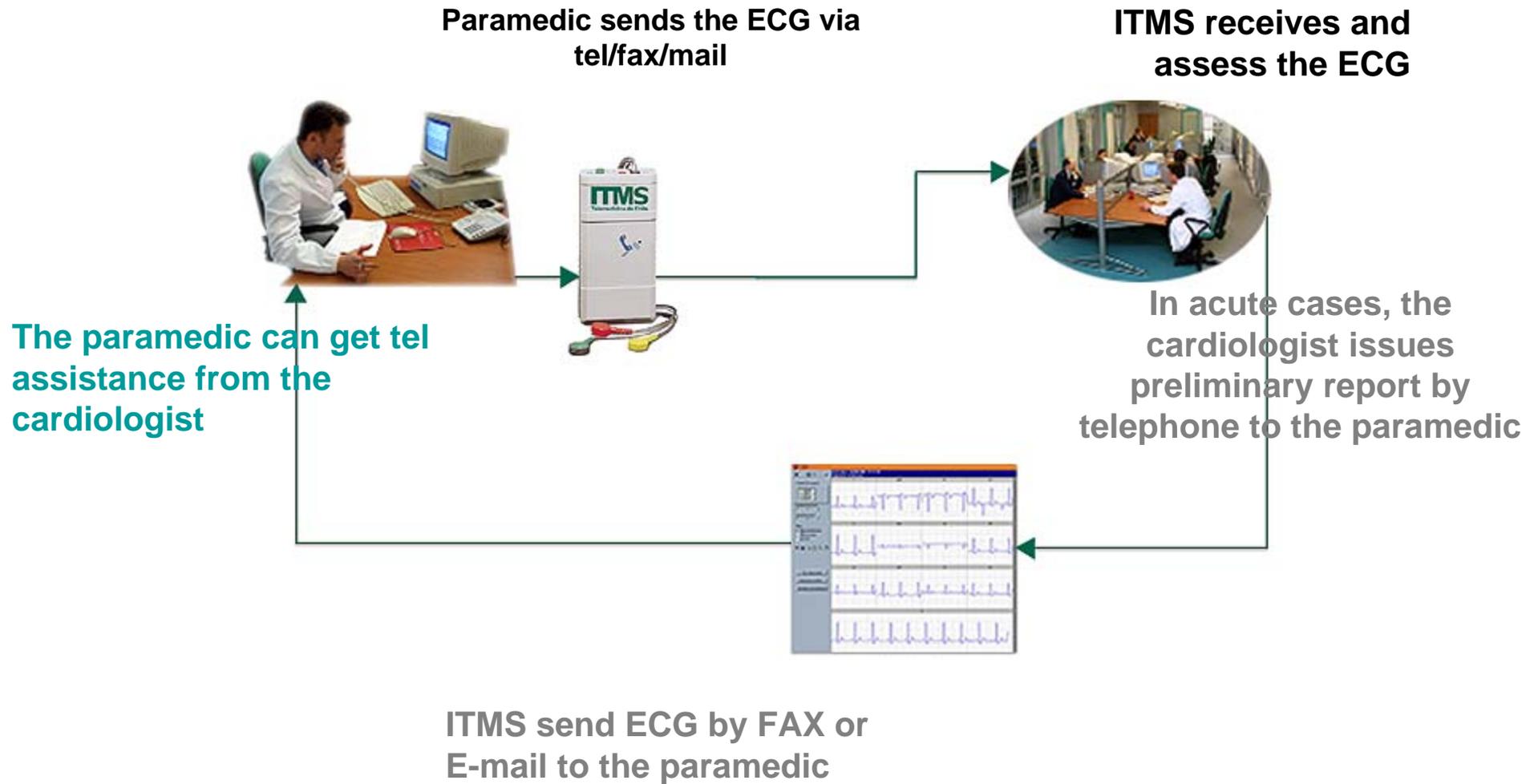


OSF First Aid Station

- 1 paramedic 24/24h – 7/7
- 1 ambulance
- Professional driver available



Telemedicine



Measures taken at ALMA first aid station



- When **AOS** worker comes with Acute Mountain Sickness, he is evaluated on the basis of a Louise Lake scoring scale (international standard). Once the severity of the condition is quantified, the subject is treated.
- The treatment is based on oxygen application, and administration of analgesics and anti-inflammatory drugs.
- Subjects not adequately responding to this treatment are descended immediately for extended testing and treatment at **OSF** first aid station.
- Subjects not adequately responding within 30 min treatment at OSF would be immediately sent to hospital. The latter has, until now, never been necessary.

Observation:

After applying the Louise Lake scoring scale on September 2008, 40 acute mountain sickness patients have been attended, 37 of them having been slight, 2 moderate, and one severe. The latter patient was sent to the OSF polyclinic. After a resting day at the campgrounds he returned to work at Chajnantor without any issue.

- Acidifying the blood stimulates ventilation, which is beneficial during acclimatization. As mentioned above, acetazolamide (name **Diamox**) is available at the polyclinic with medical prescription.

Effects of oxygen supplementation for workers' Acute Mountain Sickness at AOS



- 3 lts/min of O₂ application increases O₂ hemoglobin saturation: After one minute the improvement appears
- After one minute of oxygen application (3 lts/min) the heart rate decreases significantly, particularly in subjects with tachycardia.
- After 10 minutes of oxygen application (3 lts/min), hypoxia symptoms practically disappear.
- After 15 minutes of oxygen application (3 lts/min) the worker is prepared to gradually return to his tasks.
- Among analgesics provided at Chajnantor, a one-time doses of 500mg of Paracetamol and 400 mg of Ibuprofene showed the best results...

AU Workshop on high-altitude medicine



- Hypoxia affects sleep, unleashing a state of fatigue and drowsiness which can trigger a series of negative circumstances. These are not listed, however, for our project these circumstances relate to triggering transit or labor accidents. Two corrective responses are provided:

Workshop on high-altitude medicine – UA



- At high altitude Free radicals, derivative of O_2 , which are produced by hypoxia condition, are highly damaging lipid, protein and nucleic effects. In order to maintain a good balance and prevent an excess of free radicals, the antioxidant capacity of the body has to be reinforced by supplementing vitamin E, C and possibly Melatonin.
- Melatonin increases at night in order to guaranty the sleep and decreases by day to allow alertness, which depends on blue light.
- However blue light decrease at high altitude. Alternative source of blue light is needed.



ALMA/UA/UC MEDICAL STUDY

"OXIDATIVE STRESS AND BLUE LIGHT INVOLVEMENT IN HYPOXIA-RELATED BIOLOGICAL CLOCK CHANGES. IMPLICATIONS FOR HUMAN WORK AT HIGH ALTITUDE"

ALMA/UA/UC MEDICAL STUDY



On the basis of the enhanced developments in ground based astronomy, an increasing number of people will be exposed to high altitude conditions. Working at high altitude does have a major impact on safety, health and performance of staff, therefore, measures to improve work conditions and organization at high-altitude must be developed. ALMA initiated a research project which considers particularly those people who, within the next years, will be required to work above 5050 m (~16500 ft) altitude at the Llano de Chajnantor, district of San Pedro de Atacama.

ALMA/UA/UC MEDICAL STUDY



The “Project outline” is to be realized during the next four years on the basis of the commitments of ALMA with University of Chile (UC) and University of Antofagasta (UA).

ALMA recommended Pr. Claus Behn as Principal Investigator of the project and Dr. Juan Silva as Co-Investigator.

Further collaborations are envisaged with Prof. Vogt in Denmark and Prof. Gunga in Berlin, as well as other investigators abroad.



Feedback workers acclimatization at very high altitude.

- ALMA/UA/UC are partners:

OCEGTEL company is the main contractor on ALMA which employees are working on antennas foundations.

9 workers of them are participating in a study to measure the following parameters:

a) Blood samples to record evidence of hematological acclimatization through the levels of the hormone erythropoietin and the values of the hemogram (samples taken at the ALMA first aid station)

b) A test of cardio-respiratory function to record evidence of respiratory acclimation through non-invasive measurements of pulmonary function, oxygen consumption with ergo-spirometer Quark b2 and heart rate variability with the Polar S810, heart monitor (tests taken at rest)

The research group went 4 times to Chajnantor since July to November 2008 where they followed up the 9 volunteers. The findings of the study will be given to ALMA Project as soon as UA get them. 27

Feedback workers acclimatization at very high altitude.





ALMA High Alt Policy



END



ALTITUDE TRAINING REQUIREMENTS

The course covers the following topics:

- Introduction to acclimatization and high altitude sickness.
- Basic altitude physics.
- Physiology of respiration. Oxygen transport at sea level and altitude.
- Reduced work efficiency in high altitude and preventive measures
- Normal acclimatization to altitude.
- Patho-physiology of altitude sickness. High altitude pulmonary and cerebral edema.
- Treatment of altitude sickness (medical, non-medical, physical). Emergency medication and emergency equipment.
- Prophylaxis of altitude sickness (medical, non-medical).
- AED (Automatic External Defibrillator) use.



Physical Exam Requirements and High Altitude Policy

Annual high altitude medical exams are required for the following.

- ALMA staff with a duty station at the ALMA site
- ALMA staff with a cause to visit the ALMA site and whose activities include going above 9500ft (above the OSF)
- Contractors and subcontractors required to work on the ALMA site above the OSF, as specified in their contracts.
- Executive staff with a cause to visit the ALMA site and whose activities include going the OSF.
- This policy is not intended to replace any requirements established by the Executives.



MEDICAL EXAM REQUIREMENTS

	Less than 40 years old	40 years and older
Examination by a physician	Every year	Every year
Questionnaire on alt. experience	Every year	Every year
Hemoglobin level	Every year	Every year
ECG without stress condition	Every year	Every year
Creatinine level	First exam + Every 5 y	First exam + Every 2 y
Glycemia level (urine / blood)	First exam + Every 5 ye	First exam + Every 2 y
PA chest X-ray (if requested)	First exam + Every 5 y	First exam + Every 2 y
Pulmonary function test	First exam + Every 5 y	First exam + Every 2 y
ECG under stress conditions	First exam + Every 5 y	First exam + Every 2 y



Physical Exam Requirements and High Altitude Policy

ACUTE MOUNTAIN SICKNESS

- Acute Mountain Sickness - AMS is a term applied to a group of symptoms likely to occur in un-acclimatized people who make direct ascents at high altitude. It also occurs in people who partially acclimatize then make an abrupt ascent to a higher altitude.
- High Altitude Pulmonary Edema - HAPE is abnormal fluid accumulation in the lungs resulting from mal-adaptation to altitude. HAPE rarely occurs below 9000ft.
- High Altitude Cerebral Edema - HACE is swelling of the brain thought to be caused by hypoxia-damage to brain tissue. HACE generally occurs above 10000ft but has been recorded at 9500ft.



ABSOLUTE CONTRAINDICATIONS

- Background of cerebral ischemia.
- Chronic respiratory insufficiency
- Severe renal insufficiency
- Unstable coronary artery disease.
- Malign arterial hypertension.
- Pulmonary arterial hypertension.
- Hemoglobinemia greater than 18.7 gr/dl in men, or greater than 18 gr/dl in women.
- Severe anemia (Hb less than 8 gr/100ml).
- Thromboembolisms or blood clots.
- Creatinin clearance (Cockcroft formula) = $(140 - \text{Age}) \times \text{Weight (KG)}$

- Background of pulmonary and/or cerebral edema resistant to prophylaxis by acetazolamide, niphedipine and/or corticoids.
- Epilepsy with seizure in the last year.
- Morbid obesity (BMI > 40)
- Serious uncompensated arrhythmias
- Pregnancy.
- Recent (less than 6 months) acute myocardial infarction.
- Decompensated cardiac insufficiency, or grade III or IV compensated.

• [1] Body mass index (BMI) =
$$\frac{\text{Weight (kg)}}{\text{Height (metres) squared}}$$



RELATIVE CONTRAINDICATIONS

- Well-controlled epilepsy, no seizure in last year.
- Compensated psychiatric disorders.
- Presence of cardiovascular risk factors.
- Insulin-dependent diabetes mellitus (evaluate isolation of workplace).
- Decompensated type-II diabetes mellitus.
- Severe hypertriglyceridemia
- Decompensated systemic arterial hypertension.
- Any uninvestigated cardiac pathology.
- Other anemias (with hemoglobinemia greater than 8gr/dl).



HEALTH CERTIFICATION

- The medical certificate must mention that the worker is “Acceptable without restriction for executing his (her) work at **16500ft ~ 5050m** above the sea level”
- The medical certificate is valid for 1 year
- ALMA safety follows up the HAME validity and informs HR or individuals some weeks before expiration.