Scientific Research at the International Laboratory/Observatory Pyramid, Sagarmatha National Park, Nepal

Renato Baudo[1] and Gianni Tartari[2]

[1]CNR Istituto per lo Studio degli Ecosistemi, Largo V. Tonolli 50-52, 28922 Verbania, ITALY, Phone: + 39 0323 518312; Fax + 39 0323 556513; e-mail: r.baudo@ise.cnr.it; [2]CNR Istituto di Ricerca Sulle Acque, Località Occhiate, 20047 Brugherio, Milan, ITALY. Phone: + 39 039 2004303; Fax + 39 039 2004692: email: tartari@irsa.rm.cnr.it

The Pyramid International Laboratory-Observatory, inaugurated in 1990, is the symbol of the Ev-K2-CNR Project, a joint venture between the Italian National Research Council and the Royal Nepal Academy of Science and Technology. The Laboratory, located at 5050 m a.s.l., in the Khumbu valley, at the foot of the Nepali side of Mt. Everest, is the first semi-permanent high altitude research centre which includes a self-sufficient energy system as well as a fully equipped scientific laboratory. The Pyramid is a glass and aluminium structure, measuring 13,22 m (43,37 ft) at the base and 8,40 (25,7 ft) in height. Its geometric shape provides stability and resistance to the elements such as winds, snow and rain. The outer covering of reflective glass makes the structure environment-friendly.

The Pyramid is fully independent, using only renewable power sources: water, sun and wind. Waste is separated and disposed of by an environmentally sound Waste Disposal System.
The International Laboratory/Observatory is also equipped with videoconference facilities, allowing researchers to be involved in scientific meetings as well as teaching and awareness-raising activities.

Research in the various disciplines of Earth Sciences has always represented the core activity of the Ev-K²-CNR Project. Since 1988, under the leadership of Prof. Desio, important studies have been performed in the geodetic, geophysical and geological fields. In depth studies were carried out in the regions of K2 and Everest in order to acquire new gravimetric and geological data on one of the main collision areas between the Indian and the Asian plates.

Among the various activities in the Himalayas over the last few years, **measurement and land survey campaigns** have been of particular importance, including the re-measurement of the world's 14 highest peaks using up-to-date traditional and satellite (Global Positioning System - GPS) instrumentation. Mount Everest was measured in 1992 and then Mount K2 (1996), Mount Cervino (1999), Mount Rosa (2000) and Mount Aconcagua (2001), the highest peak in Latin America. Another important field of research within the area Earth Sciences regards **gravimetric and seismic activity** of the Himalayan chain. The installation of a seismic station in one of the most active regions of the world gives access to exceptional information which can be used for the analyses of complex geological phenomena, providing a reasonable degree of predictability for future events. Furthermore, the Pyramid can be considered a point of reference for the study of leveling lines between India and Tibet with the construction of the first GPS network in the Himalayas and installation of a station within the French "DORIS" satellite positioning system. Data acquired during Ev-K²-CNR Project expeditions has also been used to create an initial Geographic Information System (GIS) of the Khumbu valley,

integrated by satellite data. Finally, magnetism and gravimetric studies have allowed researchers to determine the thickness of the Earth's crust and to "observe" the subduction of India beneath Tibet. This data was further used to calculate the local and global Geoid in the Himalayan area.

The Pyramid International Laboratory-Observatory provides a privileged location for research in the field of Medicine and Human Physiology in extreme environmental conditions, offering the opportunity to study physiological adaptation at 5000-8000 m a.s.l., representing a valid point of reference for what happens in everyday life at more common and easily reachable altitudes.

The Pyramid can be reached after a trek of at least 4 days. It is possible to stop for few days at lower altitudes (generally at 3500 m or 4200 m) and study the same subjects in various states of hypoxia and at different levels of exposure (acute versus chronic) and acclimatization. This provides opportunities for examining the effects of limited availability of oxygen on various human physical functions, such as: modified reaction times; automatic and controlled mental processes; memory efficiency; bioenergetics of high altitude exercise; structural and functional modifications of cardiovascular system; variations in body composition and related endocrine and metabolic parameters; food absorption efficiency; effects of UV rays on the epidermis.

Not only is the Pyramid located at a higher altitude than all other similar alpine observatories even in Europe, it also provides a unique chance to study the local populations (Tibetan and Sherpa), who have lived for centuries at high and extremely high altitudes, distinguishing the Pyramid from another, similar high altitude laboratory in Bolivia. In this way, numerous physiological studies have been carried out comparing reactions of the following subjects: subjects born and raised at high altitudes (Sherpa), their descendants raised at lower altitudes, Europeans with or without previous mountain experience, etc.

The research outcomes offer valuable indications on the particular role of the genetic complement and on the adaptation of body functions in extreme conditions; moreover, they also find immediate application in various pathologies which can afflict living beings at much lower altitudes. Results can be used to the benefit of patients suffering from hypoxia for various reasons (fetal and neonatal hypoxia), or for those who, for pathological reasons, have a reduced afflux of blood to the brain. Subjecting healthy subjects to acute and/or chronic hypoxia is an excellent experimental model for the study of reactions to hypoxia in patients with cardio-respiratory pathologies, a problem an increasing number of patients must deal with (around the 0,3 % of world population).

Thus, knowledge acquired through research activities at the Pyramid International Laboratory -Observatory helps us to understand not only what happens to patients with particular dysfunctions but also what the effects on our organism are when we, for professional and/or recreational reasons, visit the mountains at altitudes above 2.500 m a.s.l.

High altitude areas in the Himalayas are an ideal location also for environmental studies.

Climate change

During early mountaineering and scientific expeditions in the Himalayan regions over the last century research on climatic characteristics was carried out, with outcomes being widely diffused in the sixties. Only in 1994, when the first automatic weather station with bi-hourly continuous monitoring of data was installed within the framework of the Ev-K²-CNR Project, did regular climate measurements at high altitudes (>5000 m a.s.l.) become possible. This monitoring process has since become known for the exceptional regularity of its measurements and marked the starting point of the Ev-K²-CNR Project's recent wider involvement in international climate and meteorological research. A landmark moment in this evolution is represented by involvement of the *Pyramid Meteo Group (PMG)* in the *CEOP/Tibet Project* as of 2002.

The CEOP Project (Coordinated Enhanced Observing Period) is part of the World Meteorological Organization (WMO) program aimed at a more thorough analysis of global climatic phenomena. Thanks to the unique characteristics of the location of the Pyramid, the PMG has been made responsible for one of the reference points in the CEOP/CAMP-Tibet sub-project. Following its inclusion in the CEOP Project, the PMG has set the following goals: carry out research at a high international level; obtain a high profile role within the International Scientific Panel, which coordinates activities on the interaction between the monsoon and the Himalayan range; insert the Pyramid station within an international circuit of highly qualified weather stations, recognised as such by major scientific institutions (WMO, NOAA, NASDA, etc).

Lake Cataloguing and Analysis

Morphological classification of the lakes of the Everest National Park began in 1990, the purpose being identification of all permanent lakes and collection of information on their size and geographic location. A series of expeditions have since been organized, leading to the realization of the Lake Cadastre or "Khumbu Valley Lakes Register", which now covers about half of the Park area. The Register, which forms the nucleus for the upcoming GIS of the Khumbu Valley, will likely be completed between 2003-2005, extending to cover the entire Everest National Park area. For this, the use of the most advanced Nepalese national cartography and up-to-date information technologies are used.

Transport of pollutants

Geographic isolation in the areas of the Himalayas, Karakorum and Hindu-Kush mountains facilitates measurement of base levels of pollutants. It is also possible to carry out measurements on atmospheric depositions (snow and rain) in the Himalayan regions, similarly to that done in polar areas, with the added advantage of easier access throughout the year. Also similar to Polar research, studies in the Himalayas have indicated the presence of certain pollutants which demonstrate a clear relationship between the concentration of these elements and cold areas. Comparative studies on rain and snow chemistry in the Khumbu Valley have however led to the conclusion that, while long distance transport of pollutants is surely important, the phenomenon has not reached levels able to produce evident environmental alterations.

Glaciers and glaciology

An important contribution to understanding global change is provided by nearly a decade of research on the glaciers of the Everest region which supply priceless information to help quantify the greenhouse effect. One key example is the activity carried out on the Changri Nup glacier where, using GPS satellite (Global Positioning System) techniques, a constant retreat of the uncovered glacier terminus and a significant increase in the size of small seasonal lakes has been documented. The glacial lakes, in fact, can cause disastrous floods, known as Glacier Lake Outburst Floods or **GLOFs**, when their natural (moraine or ice) barriers burst, leading to a sudden outpouring of water mixed with ice and debris into the valleys below. One of the most catastrophic of such events occurred in **1941 in Peru**, when over 4500 people were victims of a debris-filled flood which invaded the city of Huaràz. A recent study has indicated that 48 potentially dangerous glacial lakes are currently found throughout the Himalayas. In Nepal, memories live on of a terrible flood of mud and debris caused by a GLOF on August 4, 1985. This **GLOF** of the lake *Dig Tscho (Langmoche)* destroyed the nearly completed Namche Small Hydropower Plant, along with everything else down valley. From 1977 to 1998 5 major GLOFs have occurred in Nepal, while an **ICIMOD** study estimates 6 GLOFs between 1935 and 1981 in Tibet have been registered or are visible from satellite images. Unfortunately, the increase in global temperatures over the past 50 years is causing a noticeable increase in the formation and expansion of glacier lakes - many in Nepal that are now potentially dangerous did not exist or were only in their beginning stages 50 years ago. Continuous monitoring and careful research is thus increasingly crucial in order to avoid new tragedies and to better comprehend similar phenomena occurring closer to home in the Alps.

Study of High Altitude Vegetation and Fauna

Situated in a protected area, the Pyramid Laboratory-Observatory provides a unique opportunity for studying regional flora and fauna. Apart from important contributions regarding botanic and zoological systems, specific projects have also concentrated on reproductive ethology, ungulate conservation, phytosociology, biochemistry, vegetal physiology etc. Research has, for example, provided an opportunity for the elaboration of a management program of wild fauna as a possible economic resource in the Himalayan and Karakorum mountain regions. Another project investigates the morpho-physiological characterisation of high altitude genetic vegetal resources and their valorisation within the framework of environmental conservation and their agricultural use.

Environmental impact assessment for correct territorial use

The interest of environmental science in remote areas should not be seen as mere scientific speculation. Human presence at very high altitudes, the exploitation of land by such settlements and use of landscape resources by trekkers and mountaineers all pose urgent questions connected to the conservation and stewardship of natural resources. In order to implement sustainable development for local populations, assessments of environmental impact need to be carried out to help identify sustainable strategies and understand the ecological and economic aspects of human activities. Without adequate comprehension of these processes, the often little-known cultures of these regions risk being lost as a consequence of economic development and importation of new social lifestyles.

After 14 years of activity, with over 500 missions carried out at the Pyramid, the Ev-K²-CNR Project has become one of the main international cornerstones of high altitude and remote area scientific research.

The future activities of Ev-K2.CNR will be extended over the entire Himalaya-Karakorum range, starting in 2004, when the first automatic weather station will be installed near Mount K2, in Pakistan. This new strategy of Ev-K2-CNR aims to transfer the experience accumulated in the development of high altitude researches at local level, so that the contribution to the understanding of global change can also lead to the enhancement of the capacity building of local populations.

Further information can be found at the site: **www.mountnet.net**