THE NAICA CAVES SURVEY

GIOVANNI BADINO[1,2,5], ANTONIETA FERREIRA[3,5], PAOLO FORTI[1,6], GIUSEPPE GIOVINE[1,5], ITALO GIULIVO[1,4], GONZALO INFANTE[3,4], FRANCESCO LO MASTRO[1,5], LAURA SANNA[7], ROBERTA TEDESCHI[1,8]

[1]La Venta – Esplorazioni Geografiche
[2]Dip. Fisica Generale Uni-TO
[3]Speleoresearch&Films
[4]C/Producciones
[5]Proyecto Naica
[6]Dip. Scienze della Terra, Uni-BO
[7]Gruppo Speleo Ambientale Sassari
[8]VirtualGeo srl

The Naica caves survey is posing important technical and conceptual problems, in order to save the memory of these marvelous structures. A large effort was made to create a database of the main mega-crystals inside the Cueva de los Cristales.

Caves dimensions recorded to date are:

Cueva de los Cristales. Length (survey plots): Main chamber: 109 m, SE branch: 42 m, NE branch: 68 m. Surface: 1100 m^2. Volume: 5000-6000 m^3. Vertical Range: 12 m.

Cueva de las Espadas. Length: 105 m - Surface: 600 m^2 - Volume: 1400 m^3.

Cueva de las Velas. Length: 75 m - Surface: 400 m^2 - Volume: 1500 m^3.

Cueva Ojo de la Reina. Length: 15 m - Surface: 50 m^2 - Volume: 150 m^3.

Cueva del Tiburron: Length: 22 m - Surface: 50 m^2 - Volume: 70 m^3.

We have measured each giant crystal in Cristales (position in space, position relative to the others, and dimensions). In total, we have mapped 149 crystals, which we estimate to be more than 90% of the total. The largest crystal is Crystal Cin, in the northeast part of the main chamber. Its length is 11.40 m, with a volume of 5.0 m^3.

1. Introduction

There is general agreement between specialists that the Naica's caves, and especially Cueva de los Cristales, are the most amazing underground wonder on Earth. Unfortunately for mankind, not for the caves, we are going to lose them. In the short term, it is impossible to hope that it will be visited by a significant number of people and, in any case, its long term destiny and fortune is to return below 170 m of hot and supersaturated water. Cristales will forget us and return to its natural state. This is the cave's long-term fate. Our mission is, then, to preserve the memory of its appearance in our world as well as possible. There are many aspects of these caves that have to be understood and remembered, but surely the first to be fixed in human knowledge is their shape. To obtain a general survey of these caves has been the first goal of Proyecto Naica. The extreme adverse environmental conditions have forced us to develop new techniques and approaches to data acquisition and drawings, which are described in this work.

2. Difficulties

Any complex undertaking in Cristales meets the hostile operating environment. Surveying is particularly difficult because it requires prolonged effort, cumbersome suits, to speak one has to take off the mask and feel the hot vapor that tries to enter the lungs, and a lot of physical activity. One must, therefore, carefully prepare before entering; think a lot about what and how to do things, in order to perform them in the shortest possible time. The phase that precedes outfitting in the antechamber is, therefore, complex

and tense, then "the descent" is intense and risky. For these reasons, one tends to operate with a little anxiety, in a hurry, clumsy, time passes, must hurry, finish up... and that is exactly what should not be done. Movements must be slow and deliberate; otherwise it leads to agitation, hyperthermia, and mental confusion.

Then there are the difficulties hidden in the details, first of which is the accuracy that we want to obtain. The cave is pretty small, but it is necessary to change the level of "reproduction" here, as a normal survey isn't nearly good enough. There is another problem. What must be surveyed? In Cristales, we do not know what is important. It is a forgotten window open onto another world, a cave fundamentally alien to our speleological culture. So here, poor surveyor, even if your hands didn't tremble for other very good reasons, they would tremble in any case from uncertainty. You know that you have to collect far more information than usual, without however being sure of knowing how to select it and of actually being able to collect it.

Another very serious concern were decisions of what to draw into the map. Are the crystals the stuff that fill up the cave, or is "the cave" the one in which we pass through, that is, the part outside the crystals? Then there is the problem of the time needed in order to survey, which is very limited. A survey is an operation that should not be interrupted.

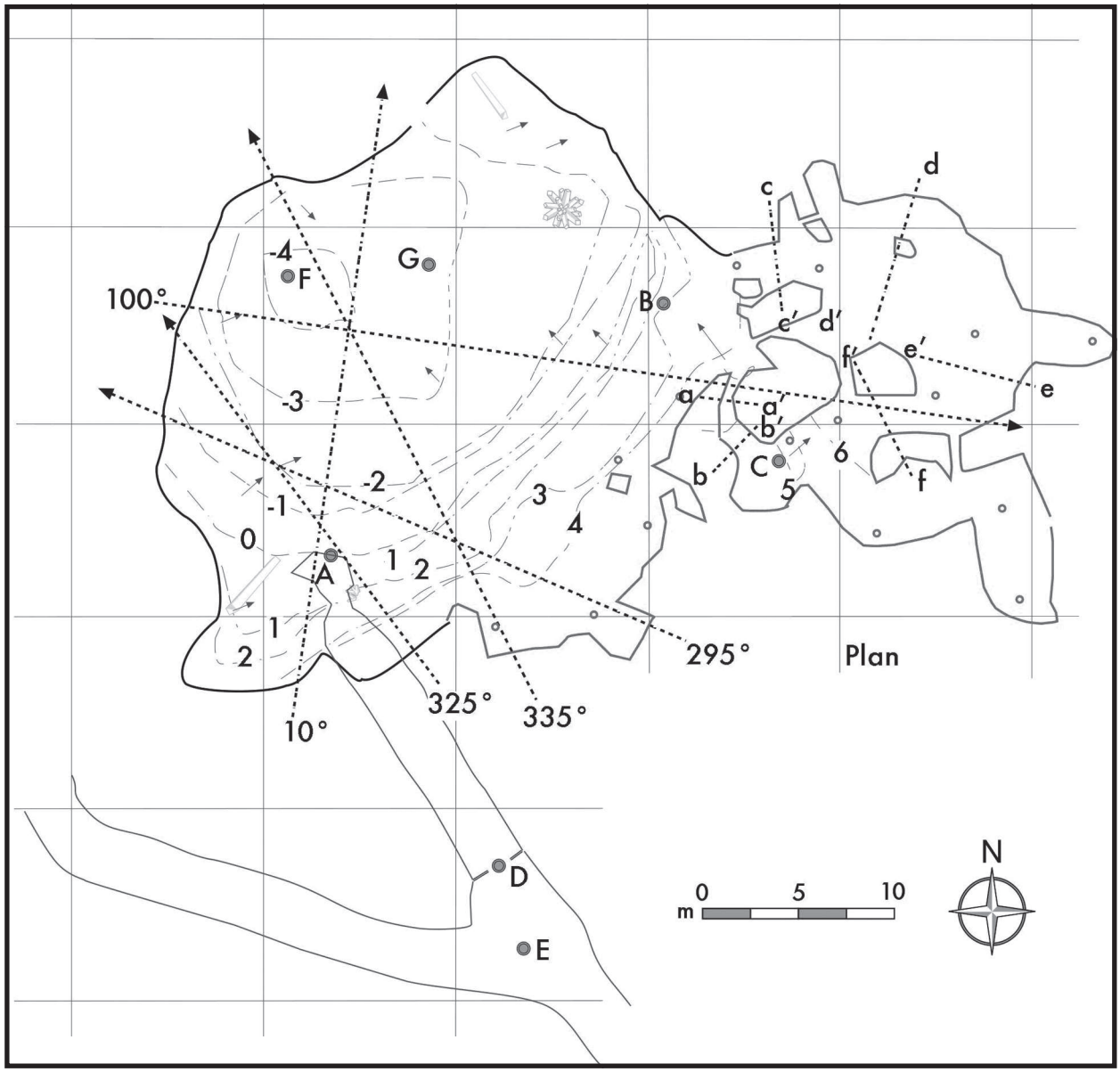

Figure 1: Plan of Cueva de los Cristales.

It should begin and end in a single session, especially if accuracy is a main goal. But, to achieve this task in that hot oven is not at all easy. Until now, the cave had never been surveyed; it is impossible to map Cristales in dozens of sessions consisting of three blistering minutes each. In addition, there is the problem of drawing. One is in a hurry, hands have great difficulties making precise movements, they shake too much; drawing is a nightmare. We noticed this problem almost immediately and found the solution: To photograph each shot, with the subject indicating the survey station number with fingers and then make the drawing itself outside. As would be expected, the instruments do not work well either. They must first be warmed up before entering (even the note pad); otherwise condensation will prevent any reading or annotation. It also goes without saying that the laser rangefinder does not work on the crystals and therefore, after practically "boiling" it in a sealed container, one must aim it at a companion or at one of the rare rock tracts that emerge from the sea of crystal. Aim is obviously often off and one tries and retries, while the clock ticks away and uneasiness transforms itself into suffering. One is tempted to resist finishing the job. To resist? That is another thing that definitely should not be done. When an explorer finally decides to exit because the situation has become intolerable, he discovers that the planned time to exit has long passed and a crisis is by now in progress.

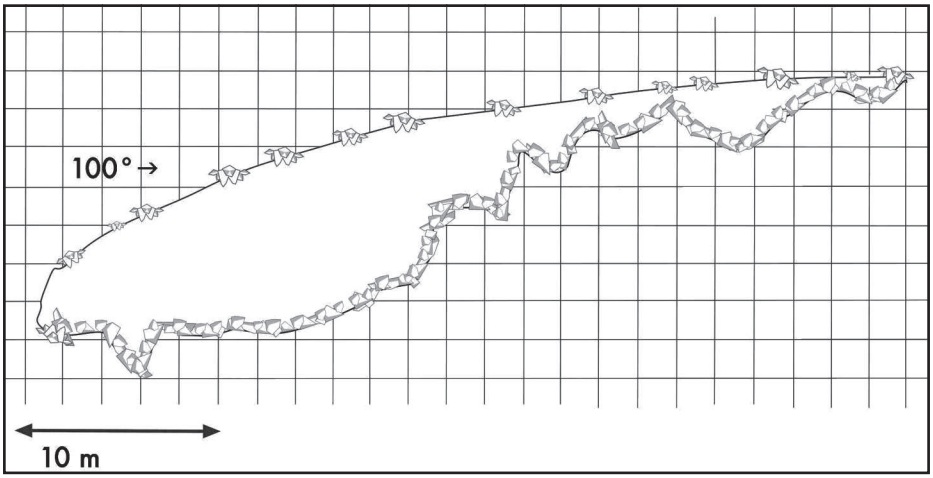

Figure 2: Section of Cristales along the 100° plan.

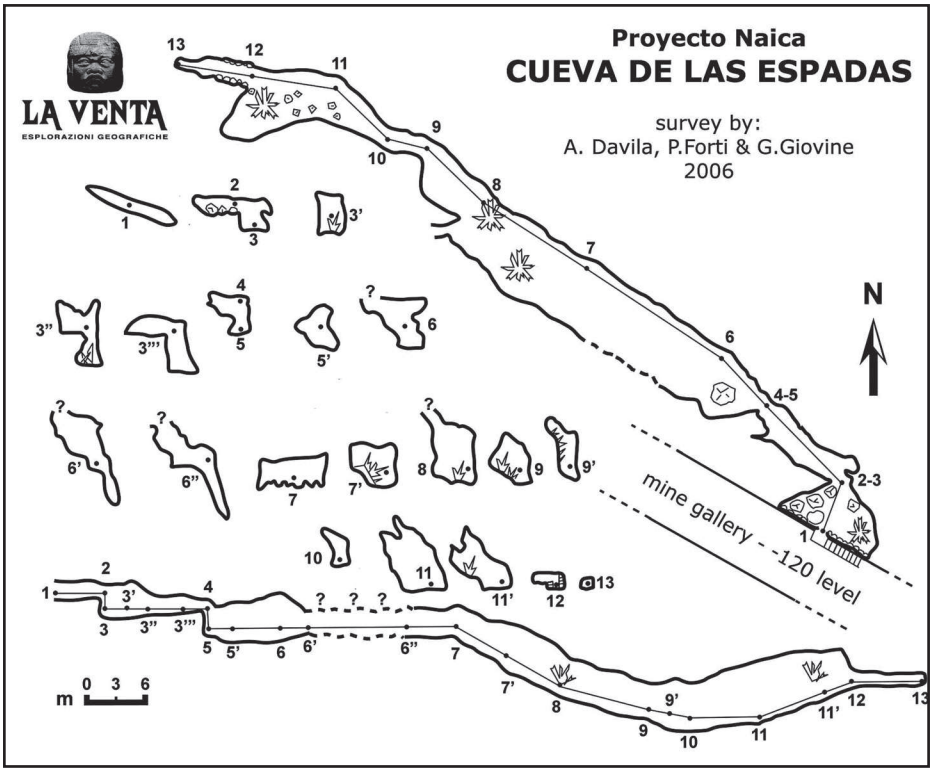

Figure 3: Plan and Sections of Cueva de las Espadas.

3. Results

Caves dimensions recorded to date are:

Cueva de los Cristales: Length (survey plots) - Main chamber: 109 m, Southeast branch: 42 m, Northeast branch: 68 m. Surface: 1100 m^2; Volume: 5000-6000 m^3; Vertical Range: 12 m (Fig. 1, 2).

The Cueva de las Espadas is the most important after the Cueva de los Cristales: Length - 105 m; Surface: 600 m^2; Volume: 1400 m^3 (Fig. 3).

Other caves into the mine are: Cueva de las Velas: Length - 75 m; Surface: 400 m^2; Volume: 1500 m^3. Cueva Ojo de la Reina: Length: 15 m; Surface: 50 m^2; Volume: 150 m^3. Cueva del Tiburron: Length: 22 m; Surface: 50 m^2; Volume: 70 m^3.

4. Mega-Crystals

We are creating a data base for a general overview of crystals in order to quantify the deposition and, possibly, for a better understanding of their formation. We measured direction and plunge of each crystal, its position relative to the surrounding ones, and estimated its length and width. In total, we mapped 162 crystals, which we estimate to be more than 90-95% of the total.

We have made many short visits, for a total of over 15 hours-man, during which we were able to measure and number a few crystals each time. Measurements were made by Konustar 10 Professional geologic compass-clinometer with direct readings to 1 degree resolution by the compass and 2 degree for vertical angle measurements. There is no correlation between direction and plunge of crystals, and the structure of these gypsum aggregates does not seem perpendicular to substratum as in most other geodes. A preferred orientation in two directions occurs (290° and 320° N).

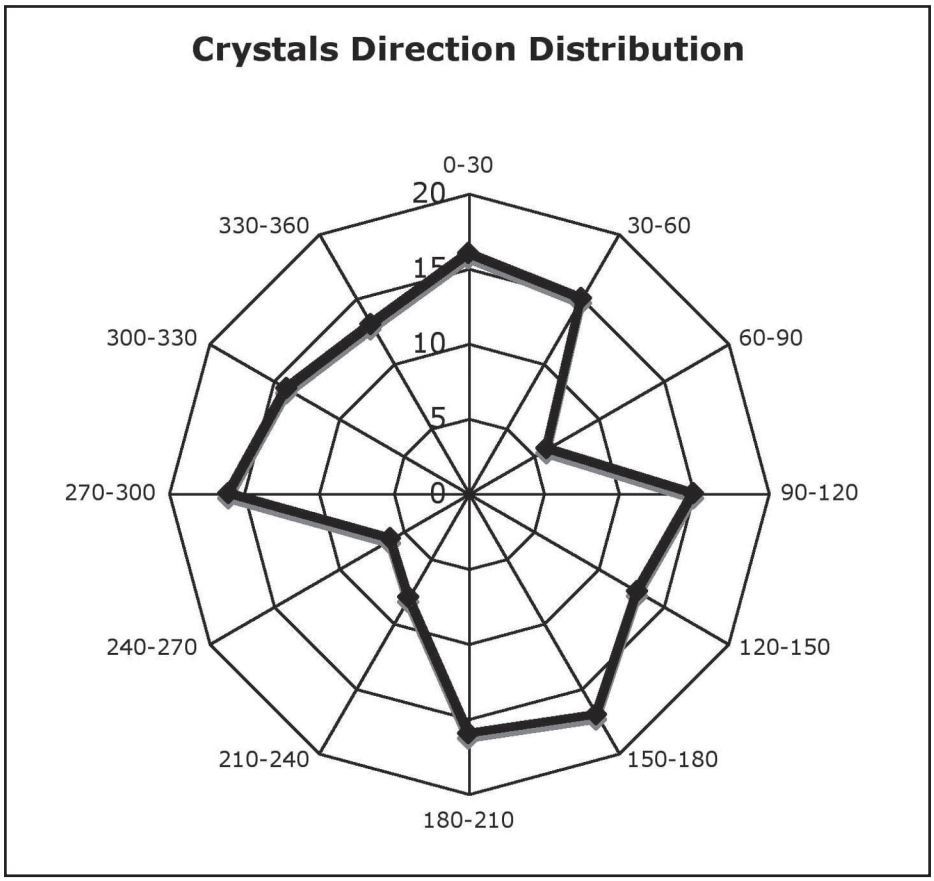

Figure 4: Cristales, distribution of crystals directions (Nm).

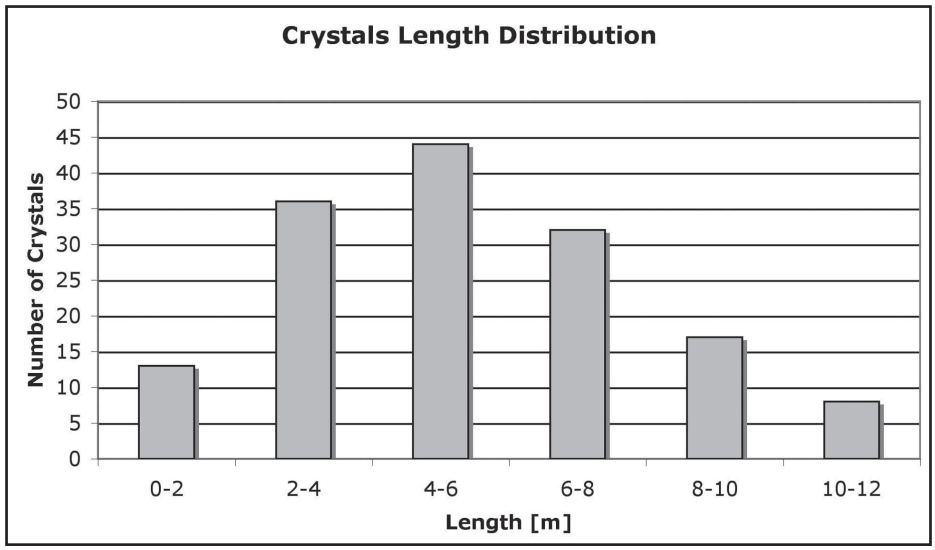

Figure 5: Cristales, distribution of crystals lengths.

In Figures 4–9, a general overview of geometrical distributions is given. In many cases, and especially where the crystals are in reality the cave wall, it was very difficult to differentiate each independent crystal. This caused some bias in the estimation of crystal volume distribution because the coalescence of different crystals was sometimes considered as a single crystal of very large volume.

Together with statistics of crystal growth, it is possible to say that, in general, we described Cristales with a detail very high for caving standard, but which is not sufficient in this case.

5. Cin Crystal

The largest crystal in Cueva de los Cristales is, until now,

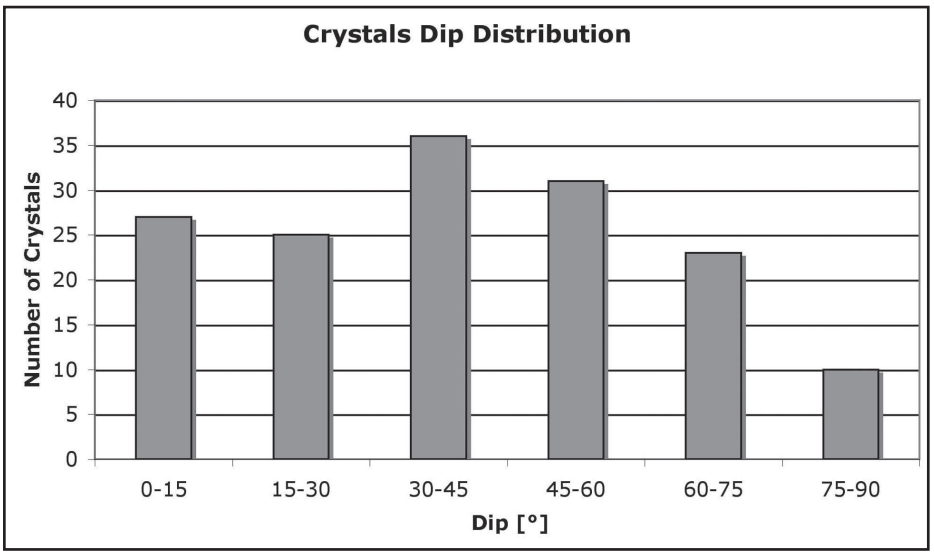

Figure 6: Cristales, distribution of crystals dips.

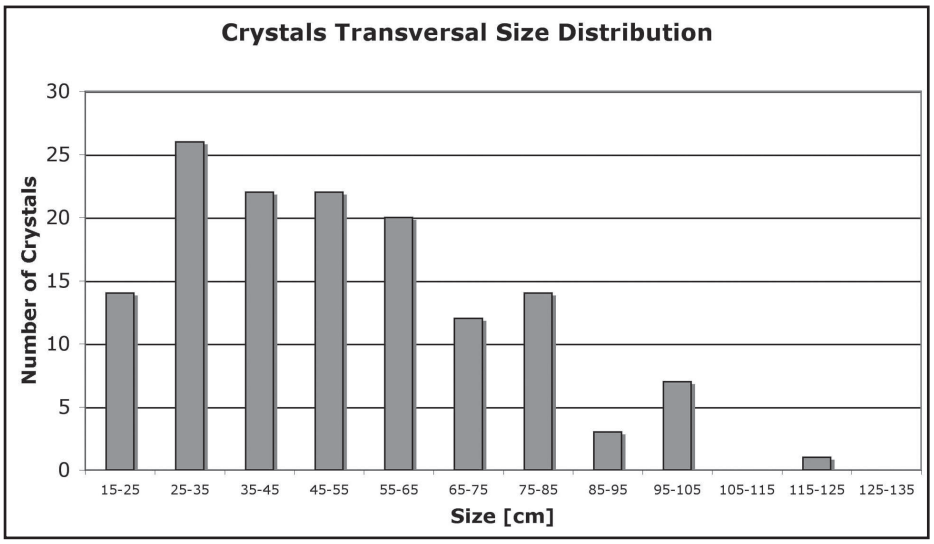

Figure 7: Cristales, distribution of crystals transversal sizes.

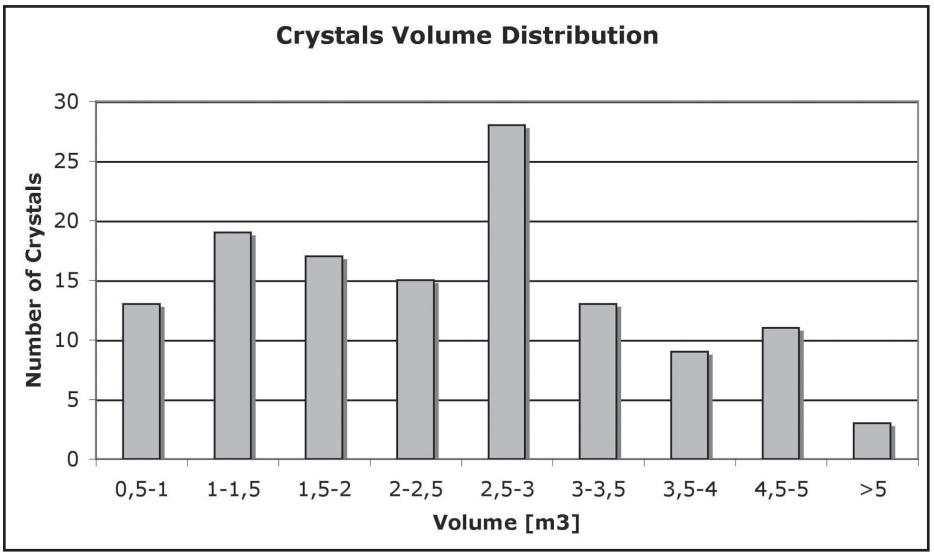

Figure 8: Cristales, distribution of crystals volumes.

a crystal in the northeast part of the main chamber. Its length is 11.40 m, with a volume of 5.0±0.2 m^3, with an estimated mass of 12 tonnes (Figs. 10 – 12). We dedicated it to the memory of Francesco Dal Cin, one of more prominent Italian cavers and member of La Venta team, recently passed away.

6. Conclusions

We worked some 20 man-hours on the Cristales cave survey, 15 for crystals measurements and 4 hours for the single Cin Crystal survey. The result is a very good cave map that is absolutely inadequate for this spectacular Cueva. Therefore, we want to make an extremely detailed 3-D survey of the Naica caves by using the best technology existing nowadays: laser scanning. Our first tests of laser measures inside Cristales gave absolutely negative results because the crystal surfaces did not return a good signal to the emitter. The standard laser-scanner has been shown unable to detect the crystal surface. Recently, we found a special model of FARO that is able to do the work. In May 2007, the company VirtualGeo performed a first test in Naica, showing that the work is feasible. We hope complete it in the middle term.

References

Badino G., 2007: The infernal survey in the Crystal Paradise,

AMCS Activities Newsletter, 30, 50

Badino G., 2008: Crystal Giants. In the caves of Naica, La Venta, 48 pp.

Figure 9: An AutoCAD 3-D model of the cave has been made. Cristales general axonometry, from NW: 149 crystals. The arrow indicates the Cin Crystal.

Figure 10: Cin Crystal, view from southwest during its survey.

Figure 11: Cin Crystal, view from west.

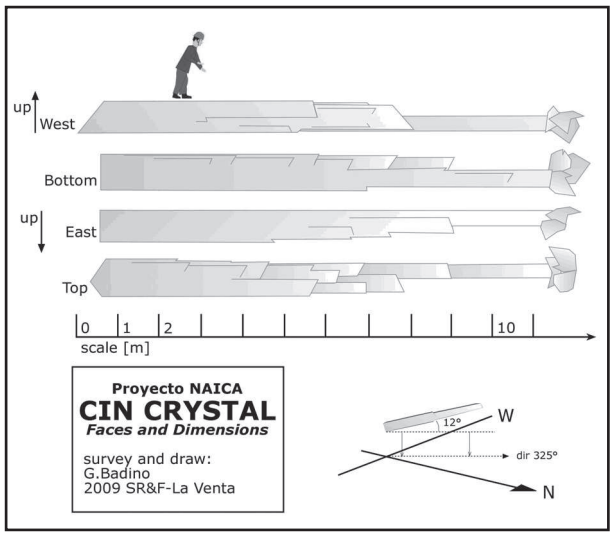

Figure 12: Faces and dimensions of Cin Crystal, the largest one.