Exploring the Universe from Chile

In northern Chile's Atacama Desert, ever larger telescopes are delving deeper into the universe but, apart from the honor of being cited in scientific publications, what's in it for Chile?

By **Ruth Bradley**

Is there life on other planets? Astronomers tend to think so and hope that a giant new telescope in Chile will take them closer to finding it or, at least, the places where it might exist.

In April, the European Southern Observatory (ESO), a 14-country alliance, selected the Armazones Mountain in northern Chile's Atacama Desert as the site for the European Extremely Large Telescope or E-ELT. With a 42-meter mirror - four times that of the largest telescope currently in operation - it will represent a massive leap in viewing power, allowing astronomers to peer into still hidden corners of the universe.

They will be looking for planets at just the right distance from their sun - neither too close nor too far or, in other words, neither too hot nor too cold - to sustain life. So far, some 400 planets have been identified outside our solar system and only one of them is in the so-called habitable zone, says Massimo Tarenghi, ESO's representative in Chile.

But as well as allowing astronomers to scout for new planets, the E-ELT will allow them to take a closer look at those already discovered. With today's telescopes, astronomers can't actually see distant planets - their faint light is obscured by that of the star around which they orbit - and only infer their existence from the star's movements or by observing the eclipses they cause.

Seeing the planet is key to gathering information about the composition of its atmosphere - "if we find evidence of ozone, we can be sure there's life," points out Tarenghi. But the search for life isn't the only reason for building the E-ELT.

Astronomers also want to see the first star that was created after the Big Bang or, in other words, to see where the universe started. What's at stake there is nothing less than the laws of physics and the question of whether, at that time, they were the same as we understand them today.

That is something that the European Organization for Nuclear Research (CERN) is also studying by using the Large Hadron Collider to recreate the conditions that existed just after the Big Bang. "It's not that our description of physics is wrong - Galileo and Newton weren't wrong - but it could be incomplete," says Tarenghi.

The view from Chile

It wouldn't be the first time that Chile has contributed to the advance of astronomy. In the mid-19th century, an expedition from the United States established a small observatory on Santiago's Santa Lucía Hill that helped to measure the distance to Mars - and was only 3.5% out - while, in the early 20th century, pioneering pictures of the Magellanic Clouds, two galaxies visible from the southern hemisphere, were taken at northern Chile's Chuquicamata mine.

More recently, in the 1990s, astronomers at the U.S.-run Cerro Tololo Observatory, near the city of La Serena, made a major breakthrough with work which helped to show that the expansion of the universe is accelerating, rather than slowing as had been assumed. That discovery was selected by Science magazine in 1998 as the most important of the year across all sciences, recalls Malcolm Smith, an astro-

nomer at Tololo and former director of the observatory.

Cerro Tololo was the first of the international observatories that have been built in Chile over the past 50 years. It was soon followed by the Carnegie Institution of Washington's Las Campanas Observatory and ESO's La Silla Observatory.

Initially, these observatories were built so that astronomers could study the southern sky. But the larger telescopes now being built are looking much further afield and it makes little difference whether they are in the northern or southern hemisphere.

Still, they have kept coming to Chile. ESO chose Cerro Paranal, 120 km south of Antofagasta, for its Very Large Telescope (VLT), which started operations in 1998, and the Gemini Observatory, a partnership that includes the United States, the United Kingdom, Canada, Australia, Brazil and Argentina as well as Chile, has one of its twin telescopes in Chile (the other is in Hawaii).

But, while it is essentially northern Chile's clear skies that have attracted these optical telescopes, the Atacama Desert also has another advantage - its dry air. That was a key factor in the decision to locate the ALMA (Atacama Large Millimeter Array) radio telescope on the Chajnantor Plateau in the Andes Mountains east of San Pedro de Atacama.

Eventually, this multinational facility, which brings together ESO with equivalent bodies from the U.S., Canada, Japan and Taiwan, will be a vast array of 66 antennas of which five are so far working, with another 16 due to start next year. "But, with just eight in operation, it will already be the world's largest radio telescope," points out Tarenghi.

Still, the decision to locate the E-ELT in Chile wasn't easy. Spain, a member of ESO, was eager to see it built in the Canary Islands and backed its bid with the offer to contribute 300 million euros. Although mostly in kind, that would have gone nicely towards outlay on the telescope which is estimated to reach 1 billion euros, whereas Chile was offering only the site near the existing Paranal Observatory.

What clinched the deal was the fact that, at Cerro Armazones, there are clear skies 320 nights in the year, a fifth more than at the proposed Canary Islands site. And that also represents money, points out Mario Hamuy, director of the University of Chile's Astronomy Department and one of Chile's representatives in the negotiations with ESO.

In Chile, astronomers will only need 20 years to do the viewing that would have taken 24 years in the Canary Islands. And, given that it will cost an estimated 100 million euros a year to run the observatory, that represents a saving of 400 million euros, notes Hamuy.

Focus on Returns

But, for Chile, allowing foreign observatories to use its clear skies is not entirely without cost. The duty-free imports to which they have long been entitled cut little ice now that the country has so many free trade agreements but, over the last few years, it has been spending to protect the observatories from light pollution.

By the 1990s, that had started to become a problem around La Serena and, in 1998, the government responded with a law to regulate and limit light emissions in the Antofagasta, Atacama and Coquimbo Regions. Over the past few years, it has gone on to spend several million dollars on a pro-

"Increasing local expertise is another reason why Chile is attractive for observatories."

Massimo Tarenghi,
ESO

Courtesy of ESO.

E-ELT, the future European Extremely Large Telescope.

gram that is gradually changing street lighting in these regions so that it points downwards, says Smith.

But Chile's clear skies - in practice, an intangible export - do have a tangible return. The money that an observatory leaves in the country where it is located is such that the 300 million euros offered by Spain for the E-ELT would have been "a high-return investment," says Tarenghi.

Due to the specialized nature of the equipment, only a small part of the capital outlay on the E-ELT will be spent in Chile. At "more than a single-digit" percentage of the total, according to Tarenghi, that's still not insignificant but it is from the operating expenses of its observatories that Chile really benefits.

Smith calculates that the observatories currently operating in Chile spend around US$100 million a year and that around two-thirds of that amount stays in Chile. Other estimates are lower - some as low as one third - but it is clear that the amount is rising as local expertise increases.

By far the largest item of expenditure for an observatory is staff and, according to Tarenghi, there are now very few areas in which observatories have to bring in overseas expertise. These are areas like optical engineering, he adds, where the situation would be much the same in many European countries.

Then, there is another bonus. Under

"International observatories are good business for Chile."

Mario Hamuy,
University of Chile

the terms on which international observatories operate in Chile, local astronomers are entitled to 10% of the viewing time.

That's a welcome injection to Chile's scant science budgets, roughly equivalent to 10% of the observatories' operating costs. And local astronomers, whose numbers have doubled over the past decade, are making good use of it, says Hamuy.

On average, they each publish 3.5 papers a year in top-level science journals, well above the international average, and they are achieving quality as well as quantity. By the standard measure of a paper's credibility and influence - the number of times it is cited by other researchers in their papers - they are close to 40% above the international average.

But, as more observatories are built, the challenge for Chile will be to increase the number of astronomers it produces, adds Hamuy, in order to provide services for these new facilities and to ensure that Chile's 10% of the viewing time is put to the best possible use. Foreign capital may, in other words, be unlocking access to

"Chile's political stability is important as well as its natural viewing advantages."

Malcolm Smith,
Cerro Tololo

Chile's clear skies but it will only be able to reach for them by creating the necessary human capital. bUSiness CHILE

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