Cosmic ray produced nuclide systematics on earth - the European contribution

Final Activity Report Summary - CRONUS-EU (Cosmic ray produced nuclide systematics on earth - the European contribution)

Quantifying the processes that shape the Earth’s surface is central to the Earth and environmental sciences. A key requirement is the ability to establish accurate absolute chronologies and rates of landscape evolution. The development of techniques to measure exceedingly low concentrations of cosmogenic isotopes that accumulate in surface rocks and soils during exposure to cosmic rays has led to an unprecedented ability to establish chronologies of environmental change over the past few thousand to several millions of years. The use of cosmogenic nuclides has revolutionised Earth surface sciences over the last decade and they form the cornerstone for the new quantitative Earth surface sciences, which are progressively replacing the traditionally qualitative techniques used in such disciplines. Advanced current applications demand accuracy of age determinations better than ~5 %. Analytical uncertainties are usually low (2-3 %). However, until recently the theoretical and empirical foundation to consistently calculate
production rates of in situ produced Terrestrial cosmogenic nuclides (TCN) was only 10-20 %.

The research program conducted within CRONUS-EU, in collaboration with the United States (US)-American sister initiative CRONUS-Earth, effectively reduced the remaining uncertainties in TCN systematics to better than 5 %, removing the obstacles for advanced applications. This occurred through experiments that refined decay constants of cosmogenic radionuclides, direct production rate determinations, laboratory cross calibrations and advanced numerical modelling. This joint research effort has delivered protocols to reliably calculate exposure ages from cosmogenic nuclide concentrations in rocks.

The activities of CRONUS-EU significantly raised the profile and the use of cosmogenic nuclide methodology in Europe; a field where Europe had been seriously lagging behind the US. In the six years since the idea of CRONUS-EU was conceived, three new dedicated accelerator mass spectrometer facilities for the analysis of cosmogenic nuclides became online, or are commissioned in Europe (Aix-en-Provence, Cologne, Rossendorf).

Training of young scientists recruited by CRONUS-EU (5 PhD students and 10 Postdoctoral researchers) was a prerequisite to conduct the work program of CRONUS-EU. The relevant knowledge base in Europe was limited prior to CRONUS-EU, and was concentrated at few centres. Training occurred in a series of network wide training events throughout Europe, and a summer school that was aimed to the wider scientific community. 90 % of the postdoctoral researchers that were employed by CRONUS-EU continue their research in Europe, about half in permanent research positions. This new generation of 'cosmogenic' researchers has a fully equitable gender balance, which is rare for natural sciences.

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