SETTING-UP CHEMISTRY LABS FOR ACCELERATOR MASS SPECTROMETRY

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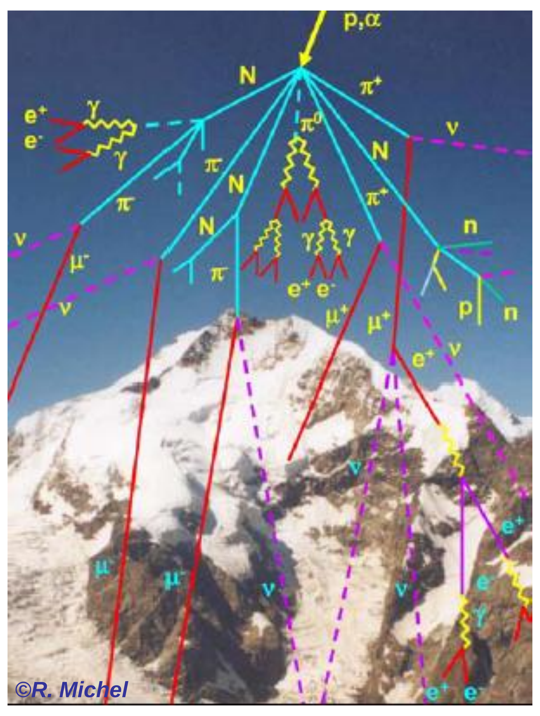
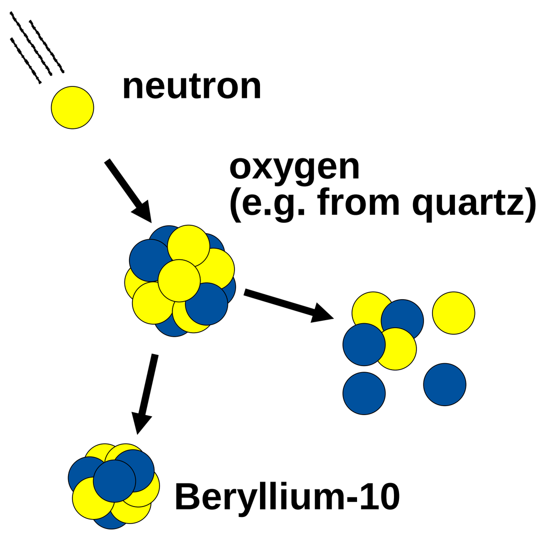
Cosmic radiation on Earth

- MeV/GeV particles (p, α, heavy ions)
- shielding (flux & energy) and transformation e.g. into neutrons by the Earth's magnetic field & atmosphere
- elemental conversion by nuclear reactions in the atmosphere ($^{14}N(n,p)^{14}C$) ››› radiocarbon-dating e.g. for archaeology or climate reconstruction from ice cores
- elemental conversion by nuclear reactions in terrestrial materials / rocks (so-called "in-situ"-production) ››› with time concentration of (radio-) nuclides increases
- irradiation of a "fresh" surface (e.g. after a volcanic eruption), reconstruction of "starting time" possible ››› "in-situ"-dating

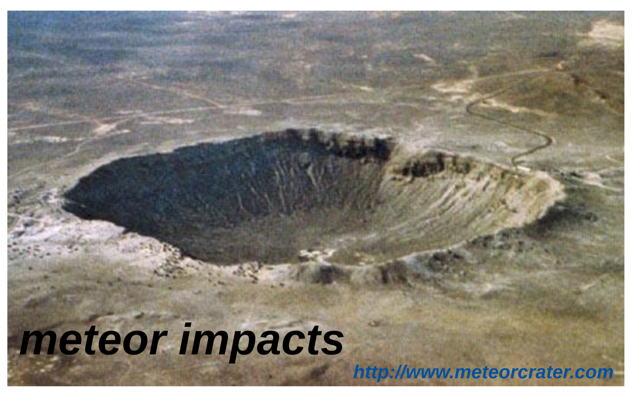


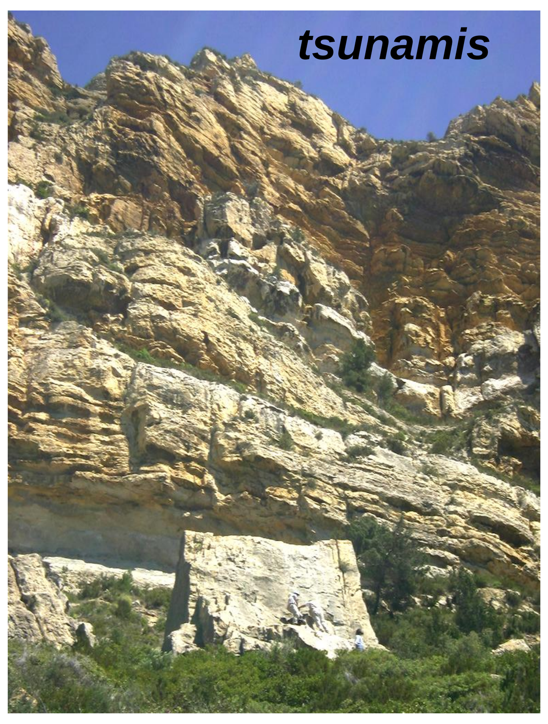


"In-situ"-produced cosmogenic nuclides (CN)

- everything having a "fresh" surface can be dated

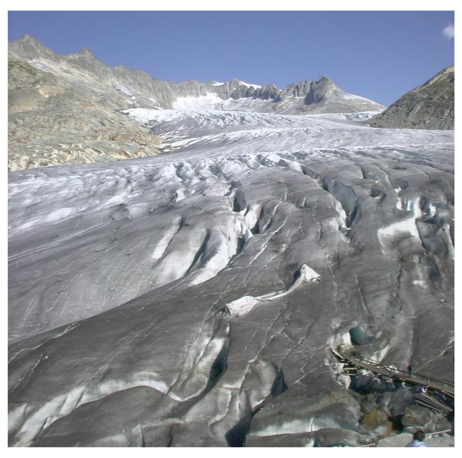
volcanic eruptions





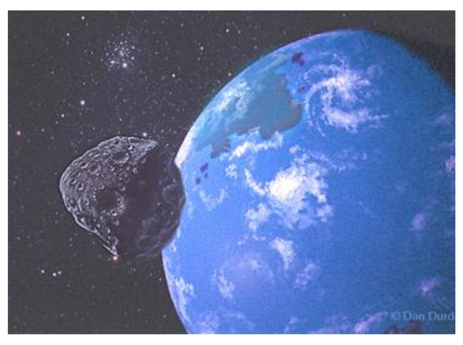
Indirect dating by CN

- climate change, e.g. via glacier movements



Special case (irradiation in space): Extraterrestrial material

- transfer times from the meteorite's parent body (asteroids, Moon, Mars) ››› irradiation age
- residence time at the place of discovery (e.g. hot desert, Antarctica) before somebody takes the meteorite home ››› terrestrial age



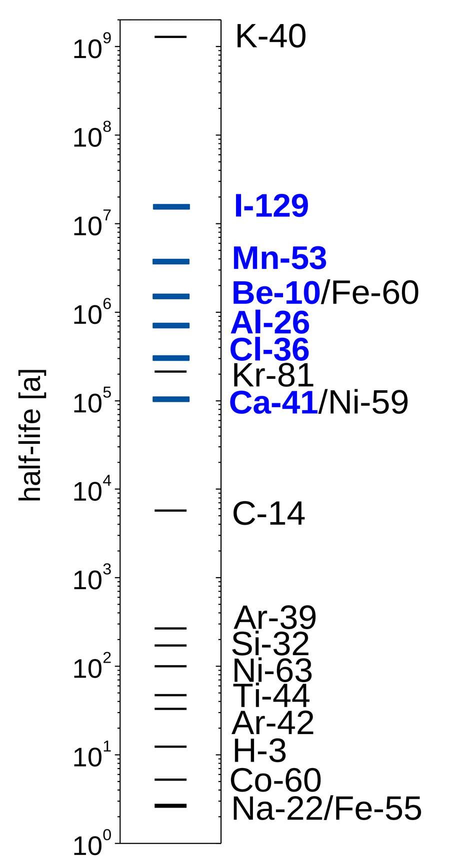
Sample preparation for accelerator mass spectrometry (AMS)

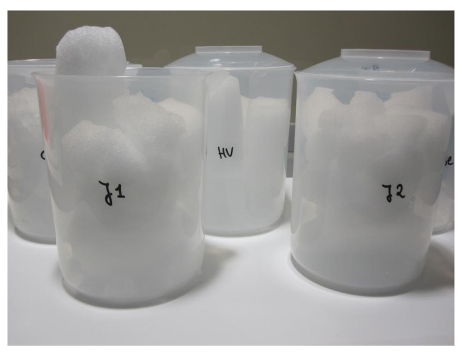
Definition of "good" AMS-chemistry

- "good " standards, i.e.
  - traceable
  - different ratios for volatile elements to avoid cross-contamination (^{36}Cl, ^{129}I)
- low machine blanks (^{10}Be)
- low stable nuclide carrier for chemistry blanks (^{10}Be)
- real sample chemistry for different matrices & nuclides
  - fast and low-cost (chemicals, man power, lab space)
  - safe (also for non-chemists)
  - low risk of cross-contamination & contamination
  - producing "pure" targets, i.e. high stable nuclide current & low isobar concentration ››› good statistics, detection limits & high sample throughput

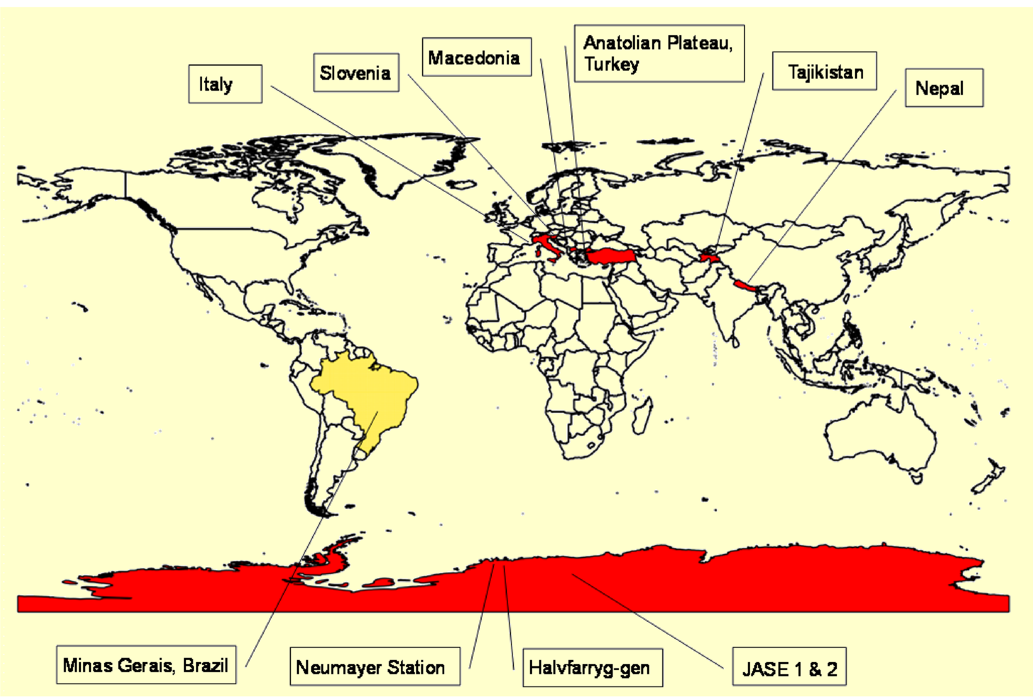
Status @ DREAMS

- standards for ^{10}Be, ^{26}Al, ^{36}Cl, ^{41}Ca, ^{129}I traceable via round-robins or cross-calibration elsewhere [ARN10, MER04, MER09, MER11]
  - special case ^{10}Be: produced via $^{9}Be(n_{th},\gamma)^{10}Be$ @ TRIGA, Atominstitut Vienna ››› $(1.73\pm0.02)\cdot10^{-12}$ $^{10}Be/^{9}Be$
  - ^{26}Al, ^{36}Cl, ^{41}Ca & ^{129}I @ 3 different ratios each 10^{-9} – 10^{-13}
- "home-made" ^{10}Be carrier & machine blank from shielded Be-containing mineral (phenakite - Be_2SiO_4) [MER08]
- speeded-up ^{10}Be-chemistry for ice core sample (5 d → 24 h / 10 samples)
- development of ^{53}Mn-chemistry for "in-situ" samples (marcasite/pyrite/realgar)
- ^{10}Be & ^{36}Cl targets from "in-situ" samples (SiO_2 & $CaCO_3$) measured @ ASTER & VERA ››› chemistry blank at least one order of magnitude lower than samples & high current
- chemistry training of external partners (non-chemists) for ^{10}Be & ^{36}Cl from "in-situ" samples satellite labs @ U Rennes & U Freiberg

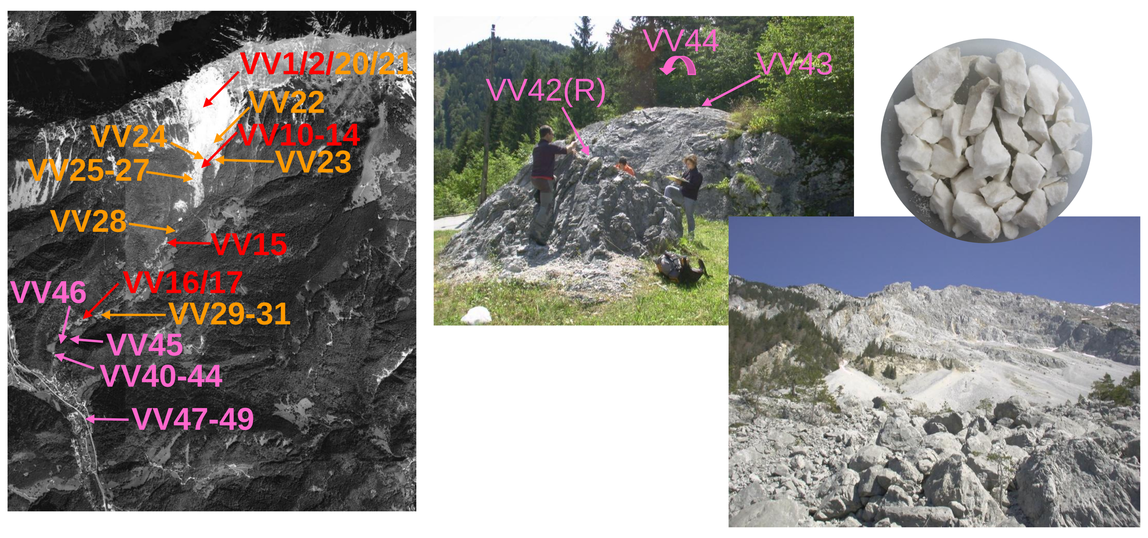




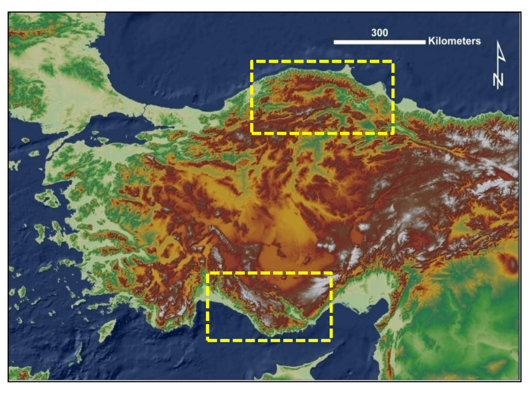
Selection of sample origins & applications



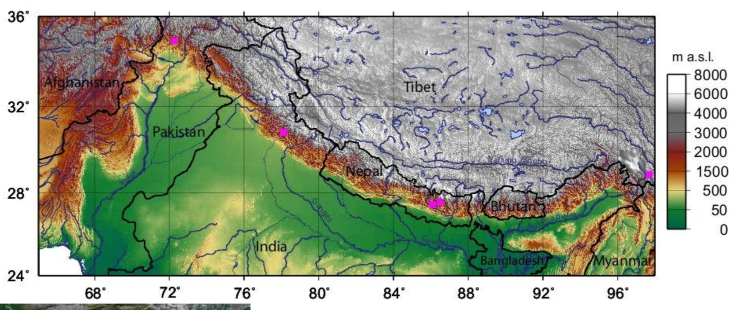
- Historical rock fall @ Veliki Vrh, Slovenia ››› Calibration site for production rate (^{36}Cl)

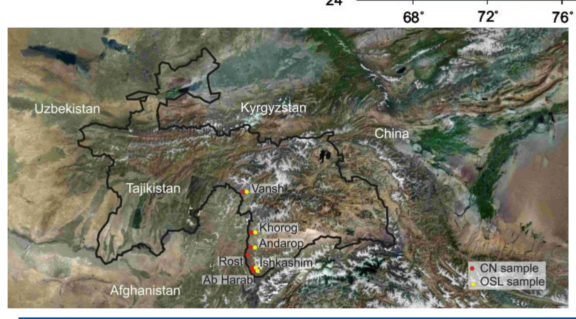


- Vertical Anatolian Movement Project ››› Uplift rates (^{36}Cl)



- Geomorphology @ Himalaya & Pamir ››› Basin-wide erosion rates (^{10}Be)





Detection limits of AMS can be as low as 20,000 atoms/g or 10^{-9} Bq.

Summary & Outlook

Routine radionuclides will be measured @ the DREsden AMS facility (DREAMS) first - except ^{14}C. Generally, all long-lived radionuclides and stable nuclides can be measured by AMS. But due to the low precision of AMS (% to ‰), stable elements marked in yellow can only be measured if ratios are highly different from natural isotope ratios. Probably, other MS methods yield better results at normal isotope ratios.

routine, sophisticated with long-lived radioactive nuclide(s), stable isotopes only

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po*	At	Rn
Fr	Ra*	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	112	113	114	115	116		118

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
Ac*	Th	Pa*	U	Np	Pu	Am	Cm	Bk*	Cf	Es	Fm	Md	No

* only one long-lived radioactive isotope / no stable isotope –> very sophisticated set-up

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