# Dating of Ferromanganese Encrustations with $^{53}$Mn

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Hydrogenetic deep-sea ferromanganese crusts reflect the changes of the chemical composition of sea water on geological time scales. They grow extremely slowly with only a few mm/Myr and cover time spans up to 60 Myr. Therefore, they are an important archive for the reconstruction of paleoceanographic, paleogeographic, paleoclimatic, and even „paleoastronomic“ [1,2] events, provided a reliable dating method is available.

Usually, ferromanganese crusts are dated radiometrically. The assumption of a known input of a radionuclide and the measurement of its decrease with depth allows a determination of the crust's growth rate and hence gives an age-to-depth relation. Because of the relatively short half-life of $^{230}$Th (75 kyr), age determinations are only possible up to a few $10^5$ yr [3] utilizing nuclides from natural decay chains. Another possiblility is the use of cosmogenic isotopes, which are produced by nuclear reactions of cosmic rays within the Earth's atmosphere. Dating with the cosmogenic nuclide $^{10}$Be ($T_{1/2} = (1.51 \pm 0.06)$ Myr) is possible up to $\approx$ 10 Myr [4]. However, the production rate of $^{10}$Be depends on the magnitude of solar and geomagnetic fields, which deflect cosmic rays. Cosmic ray fluxes and thus $^{10}$Be production rates in the past are not exactly known. For older crust layers, ages can be estimated applying the so-called cobalt method [5], which assumes a roughly constant cobalt flux into the crust and the growth rate $R$ can be estimated to $R[\text{mm Myr}^{-1}] = 1.28/(C_{Co}[\%]-0.24)$. This method is, however, of limited precision and only applicable to crusts with high cobalt content.

In this study the feasibility of dating with $^{53}$Mn ($T_{1/2} = (3.7 \pm 0.2)$ Myr) is being investigated, which is advantageous for different reasons:

i) $^{53}$Mn has more than twice the half-life of $^{10}$Be, thus dating of longer time spans should be possible.

ii) $^{53}$Mn is not significantly produced in the atmosphere (due to the lack of targets heavier than argon) but only in extraterrestrial dust particles. Therefore, its input is not influenced by geomagnetic field fluctuations[1].

iii) For an AMS measurement sample masses as low as 50 mg are sufficient.

In [4] a $^{10}$Be depth profile of a hydrogenetic ferromanganese crust has been reported. The crust originates from the Central Pacific at a depth of 4800 m. For the top 16 mm (6-7 Myr) no changes in the growth rate are observed. An exponential fit to the measured $^{10}$Be/$^{9}$Be isotopic ratios yields a growth rate of $(2.24 \pm 0.16)$ mm Myr$^{-1}$. If one uses - instead of the isotopic ratios - the $^{10}$Be concentration (atoms per gram) a slightly higher growth rate of $(2.75 \pm 0.20)$ mm Myr$^{-1}$ can be deduced.

From the same crust, 21 layers of 2 mm thickness were carried off, corresponding to a total time span from 0 to 13 Myr B.P. Presently, we have determined the ratios $^{53}$Mn to stable manganese in 13 layers with accelerator mass spectrometry at the GAMS setup [6]. The results are shown in the upper panel of fig. 1. In the lower panel, the isotopic ratios are decay corrected with the $^{10}$Be ages[2]. There is no evidence for a deviation from a constant $^{53}$Mn flux. An exponential fit to the data points from 0–16 mm (the region with a constant $^{10}$Be growth rate) yields a growth rate of $(2.23 \pm 0.28)$ mm Myr$^{-1}$ which perfectly agrees with the $^{10}$Be value.

The instrumental background was below $10^{-14}$. Thus, in conclusion, dating of ferromanganese crusts with $^{53}$Mn is possible up to about five half-lives or nearly 20 Myr.

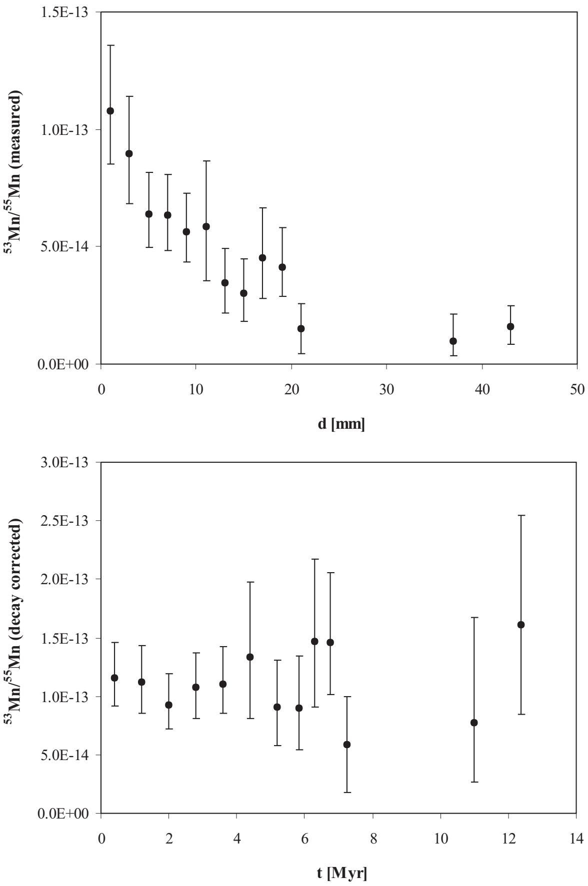


Fig. 1: *upper panel:* $^{53}$Mn/$^{55}$Mn ratios versus layer depth in the manganese crust.
*lower panel:* decay corrected $^{53}$Mn/$^{55}$Mn ratios versus the $^{10}$Be age[2] of the respective layer.

## References

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[1] However, a constant flux of extraterrestrial matter has to be assumed. On the other hand, changes in the flux of extraterrestrial matter in the past can be reconstructed, if one assumes a constant (or known) long term geomagnetical field.

[2] The average of the ages deduced from the $^{10}$Be concentrations and the $^{10}$Be/$^{9}$Be isotopic ratios, respectively, has been used.