Supplementary Material

# Co chronometry

The Be chronometry provides highly reliable age estimates but is limited to ages up to ~10 Ma owing to its relatively short half-life (15 My) (Frank et al., 2002). To address this limitation, the Co chronometry is commonly used. The empirical equation for Co age dating proposed in previous studies is based on correlations with 10Be dating results (Puteanus and Halbach, 1988). However, the 10Be/9Be ratio, which is controlled by 10Be, varies depending on the water mass (Frank et al., 2002; Ku et al., 1990); thus, it is necessary to verify whether the ratio can be applied to the study area of interest. In this study, the 10Be ages of Fe-Mn crusts from a nearby seamount (KC-8) were obtained and a modified empirical formula for the Co chronometry was applied. Equation was $R \left(growth rate\right)=1.7×(WCo^{n})^{-1.67}$ (Eq.1), which is differs from the previous proposed $0.68×(WCo^{n})^{-1.67}$ by Manheim and Lane-Bostwick, (1988) (Moon, 2016).

$WCo^{n}=Co×50/(Fe+Mn)$ (Manheim and Lane-Bostwick, 1988)

For the lower parts of the Fe-Mn crust, where Fe, Mn, and Co depletion are expected due to phosphatization (analysis point 7-10), the equation suggested by Puteanus and Halbach, (1988) was applied. The Co content used in the equation was corrected by P content and Mn/Co ratio.

$G (mmMa^{-1})=1.28/[Co \left(\%\right)-0.24]$ (Puteanus and Halbach, 1988)

# Supplementary Tables

**Supplementary Table 1.** Elements concentrations of the Fe-Mn crust (DGCR1314U01).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Analysis point | Co(ppm) | Fe(wt.%) | Mn(wt.%) | P(wt. %) |
| 1 | 4497 | 16.48 | 18.30 | 0.50 |
| 2 | 4154 | 15.70 | 17.38 | 0.41 |
| 3 | 7016 | 16.69 | 26.26 | 0.39 |
| 4 | 6016 | 16.24 | 25.79 | 0.37 |
| 5 | 4220 | 17.60 | 22.68 | 0.40 |
| 6 | 7159 | 17.26 | 27.34 | 0.47 |
| 7 | 6143 | 9.95 | 26.48 | 1.49 |
| 8 | 3961 | 7.35 | 23.46 | 3.51 |
| 9 | 2535 | 6.55 | 17.57 | 5.33 |
| 10 | 2357 | 4.48 | 13.85 | 6.12 |

**Supplementary Table 2.** Ages of the layers in the Fe-Mn crust (DGCR1314U01).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Analysis point | Top(mm) | Bottom(mm) | Depth(mm) | Thickness(mm) | Growth Rate (mm/Ma) | Age (Ma) |
| 1 | 0 | 10 | 5 | 10 | 3.52 | 2.84 |
| 2 | 10 | 20 | 15 | 10 | 3.7 | 5.54 |
| 3 | 20 | 30 | 25 | 10 | 2.38 | 9.74 |
| 4 | 30 | 40 | 35 | 10 | 2.97 | 13.1 |
| 5 | 40 | 50 | 45 | 10 | 5.01 | 15.1 |
| 6 | 50 | 60 | 55 | 10 | 2.45 | 19.18 |
| 7 | 60 | 75 | 67.5 | 15 | 2.06 | 26.45 |
| 8 | 75 | 85 | 80 | 10 | 2.69 | 30.17 |
| 9 | 85 | 95 | 90 | 10 | 3.11 | 33.39 |
| 10 | 95 | 110 | 102.5 | 15 | 7.39 | 40.78 |

# References

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