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# Revisiting the systematic classification of iron meteorites

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As of February 2025, the Meteoritical Bulletin Database (MetSoc) lists 77,053 meteorites, including 717 magmatic iron meteorites. The classification of iron meteorites involves chemical analysis to determine concentrations of siderophile elements, ranging from refractory elements like nickel (Ni) to more volatile ones like germanium (Ge) **[1]**. However, there is a large disparity of elemental availability for each meteorite and of analytical techniques to measure those elements. We want to test here if using as many elements as possible in the classification process may enhance accuracy. In this meta-analysis, we aim to classify magmatic iron meteorites across all groups by systematically utilizing available data for Ni, Co, Cr, Cu, Ga, Ge, As, W, Ir, and Au. We performed Principal Component Analysis (PCA) on a database of 596 magmatic iron meteorites to assess the relevance of each element. Our results indicate that all ten elements contribute to the variability between the groups and, therefore, are needed for classification. We then compare the standard classification in the MetSoc database with our systematic classification, which includes up to ten elements for each sample. For some groups, the classifications align perfectly, such as the IIF and IVB groups, while for others, such as IC, IIC, and IIIE, discrepancies occur. This suggests that a majority (or nearly all) meteorites in the IC, IIC, and IIIE groups could be classified differently when using our systematic approach. Based on these findings, we recommend revising the classification thresholds for magmatic iron meteorites **[2]** to reflect the advances in analytical methods. Since the early days of meteorite classification, analysis techniques have improved, and this has resulted in the use of various methods. Currently, some meteorites in magmatic iron groups are classified using Instrumental Neutron Activation Analysis (INAA), others with Inductively Coupled Plasma Mass Spectrometry (ICP-MS), and some with Laser Ablation prior to ICP-MS (LA-ICP-MS). We explore whether these methods can be integrated or if they should be considered separately in the classification process.

**[1]** Lovering et al., (1957) *Geochimica et Cosmochimica, Acta* 11, 263-276.

**[2]** Grady M.M. et al. (2013) *Cambridge University Press*