The role of volatiles in the formation of basaltic to kimberlitic maar-diatreme volcanoes, and its wider implications

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Maar-diatreme volcanoes are one of the most common volcanic landforms on Earth and the associated magmas span in composition from rhyolites via basalts, to the alkaline series (nephelinites, melilitites, kamafugites) and kimberlites. Traditionally, maar-diatreme volcanism has been attributed to interactions with a relatively shallow external water source (i.e., phreatomagmatism) producing fine-grained juvenile deposits mixed with a high degree of country rock. In recent years, new research has showed that there are significant differences between basaltic maar-diatreme volcanoes and those of the alkaline series (as well as the kimberlites). This difference can be related to the volatile content of the magmas involved. Generally, low polymerization in the melt structure allows for more CO_2 to be dissolved under pressure. For example, melilittic magmas can hold up to 18 wt.% CO_2 dissolved at 2 GPa pressure (Brooker et al., 2001). These magmas also rise (decompress) rapidly upon ascent (8-36 ms^{-1}; Mattsson, 2012), which leads to violent exsolution of volatiles and fracturing/incorporation of country rock during ascent. Thus, although basalts and the alkaline magma series produces similar landforms on the surface of the Earth, the mechanisms behind are fundamentally different. This early exsolution of CO_2 at depth during decompression, and incorporation of mantle material, may also explain why some kimberlites are diamondiferous whereas others are not. However, the near vent deposits of most kimberlitic maar-diatreme volcanoes are poorly preserved and altered. Therefore, more focused studies of the better-preserved alkaline magma series (e.g., melilitites) may provide important information on the emplacement mechanisms of kimberlites.

References:

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