ACAPULCOITE-LODRANITE METEORITES: BROADENING OUR VIEW OF A PARTIALLY-DIFFERENTIATED ASTEROID

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Introduction: In the past 30 years, the number of meteorites from the acapulcoite-lodranite parent body has increased dramatically, with 138 individual meteorites possibly representing more than 100 distinct pairing groups [1]. With the recognition of the falls Acapulco [2] and Lodran [3], the basic dichotomy within the group was established. Interestingly, these remain the only falls among the group. Acapulcoites are finer-grained, equigranular rocks of essentially chondritic mineralogy with evidence for Fe,Ni-FeS melting, while lodranites are coarser-grained rocks, often residues depleted in plagioclase and troilite as a result of basaltic and Fe,Ni-FeS melting and melt migration [4-6]. Numerous authors [e.g., 7] have demonstrated that the group is more complicated than this simple dichotomy, with both transitional members and a range of both acapulcoites and lodranites. With the number of distinct meteorites now exceeding ~100, a re-examination of the acapulcoite-lodranite clan has the potential to reveal new insights into asteroid heating and differentiation.

Mafic silicate and oxygen isotopic compositions: As a group, the acapulcoite-lodranite clan exhibits mafic silicate compositions (Fa_{3-15}) intermediate between enstatite and ordinary chondrites and oxygen isotopic compositons ($\Delta^{17}O$ = -0.8 to -1.5‰) below the terrestrial mass fractionation line. The full range of mafic silicate compositions has expanded slightly with these new finds, but many of the extreme members lack confirming oxygen isotopic compositions. NWA 4236 ($Fa_{19.2}$) has been classified as an acapulcoite, but is likely not related to the clan. NWA 6875, 10043, 10544 and 10207 populate the upper end of the mafic silicate trend, but lack oxygen isotopic data, while four acapulcoites (GRV 021663, NWA 090, NWA 4816, Y 983237) and three lodranites (NWA 7312, NWA 10155, and Y 983119) have mafic silicate compositions that overlap the range of winonaites/IAB irons and lack oxygen isotopic data. With the substantially expanded data set, the weak correlation between olivine (Fa) and oxygen isotopic ($\Delta^{17}O$) suggested by [6] persists. Originally suggested as inherited from the chondritic precursor [6], this could also result from early aqueous alteration and subsequent dehydration [8].

Range of heating in the acapulcoite-lodranite clan: The large number of new members has revealed a significantly greater range and diversity in thermal processing. While rare relict chondrules are found in several acapulcoites, GRA 98028 [9] and GRV 020043 [10] contain moderately abundant chondrules, with the latter having been classified as petrologic type 4 with ~37 vol.% chondrules. Mean chondrule sizes in GRA 98028 are incompatible with previous suggestions of a CR chondrite precursor [11]. At the other extreme in thermal processing, evidence of significant melting and melt migration of both Fe,Ni-FeS and silicate melts are known from these groups. Metal-sulfide veins are present from the µm- to the cm-scale, with the most dramatic examples in the Monument Draw acapulcoite [4] and the transitional member GRA 95209 [12]. GRA 95209 is isotopically and mineralogically unusual in preserving marked carbon isotopic heterogeneity inherited from the precursor with a range of exotic phosphates likely formed through oxidation/reduction reactions. Silicate melting and melt migration are evident in aug-opx-plag±metal-sulfide lithologies in LEW 86220 [13] and the FRO pairing group [14]. Melting up to ~35 wt.% at temperatures up to 1200°C is suggested for the latter [13]. Despite these high temperatures, no obvious reaction textures are observed, save a troilite-silicate symplectite common in lodranites. Unfortunately, LEW 86220 and the FRO meteorites are all ≤25 g, while Monument Draw and GRA 95209 are ~0.5-1 kg. The small size of many acapulcoites and lodranites exacerbates the difficulties in comparing different members of the group. If GRV 020043 is confirmed as petrographic type 4, with typical metamorphic temperatures of 600-700°C, the acapulcoite-lodranite parent body would exhibit a similar range of peak temperatures (~650-1250°C) as a typical ordinary chondrite parent body (~300-900°C), but shifted to higher temperatures, consistent with earlier accretion [15].

Summary: The dramatic growth in the number of acapulcoites and lodranites could offer significant new insights into the thermal history of a partially-differentiated asteroid. While a number of authors have addressed these interesting new meteorites individually, a comprehensive overview study is overdue.

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