PYROXENE DISTRIBUTION COEFFICIENTS, THE SHERGOTTY PARENT MELT, AND METASOMATIC ALTERATION. G. McKay (SN4, NASA-JSC, Houston TX 77058), J. Wagstaff, and L. Le (Lockheed, 1830 NASA Rd. 1. Houston, TX 77258)

INTRODUCTION. Despite extensive study by the Shergotty Consortium (see [1] and ref's. therein), chronology and petrogenesis of the Shergotty meteorite remain controversial. One aspect of this controversy concerns whether Shergotty has undergone metasomatic alteration [2,3]. Another concerns the Sm/Nd ratio of the Shergotty parent melt (SPM), and the resulting implications for the complexity of melt generation processes. While Shergotty's bulk Sm/Nd > chond, the source region (SR) is constrained by isotopic systematics to have Sm/Nd < chond [2,4,5]. If $Sm/Nd_{SPM} < Sm/Nd_{SR}$, this melt could have been generated by simple processes such as equilibrium partial melting of common mafic mineral assemblages [6]. However, if $Sm/Nd_{SPM} > Sm/Nd_{SR}$, more complex processes (e.g., batch melting [7]) are required.

Because Shergotty is a PX cumulate, the composition of its parent melt must be inferred from bulk or mineral compositions and appropriate PX/Liq D's. Following [8], Smith et al. [6] noted a correlation with Fe/Mg among literature phenocryst/matrix D(CPX,REE) (Fig. 1, data from [9]), and used D's so derived to obtain $Sm/Nd_{SPM} < Sm/Nd_{SR}$, and hence inferred simple petrogenetic processes. McKay et al. [10,11] experimentally measured D(REE,PX/L) for PX and melts similar in major ele. comp. to the homogeneous magnesian cores of Shergotty PX phenocrysts and the inferred SPM of [12], found much lower D's than those used by [6] (Fig. 1), consequently obtained $Sm/Nd_{SPM} > Sm/Nd_{SR}$, and hence inferred complex petrogenetic processes. This conclusion rested on two assumptions: First, that only the homogeneous PX cores are cumulus (the zoned rims being adcumulus [12]), and second, that Shergotty has been a chemically closed system since crystallization (a requirement of the method used to calculate the trace element (TE) content of the melt [13]). If portions of the zoned rims are cumulus [14], and if D's increase markedly with Fe/Mg [6], previously measured D's [10,11] would not apply, and effective D's might be large enough to permit $Sm/Nd_{SPM} < Sm/Nd_{SR}$. Also, if the bulk REE content of Shergotty has been altered since crystallization, the method used to compute melt TE content is invalid, Sm/Nd_{SPM} becomes poorly constrained, and little can be inferred about the processes by which the SPM was generated.

In this abstract we report D's measured for evolved PX and melt derived through ~50% crystallization of a synthetic SPM starting composition, thereby addressing the case in which portions of the zoned PX rims are cumulus. In addition, we discuss implications of recently reported Sm and Nd analyses of separated pyroxenes [2,3] for the issue of whether Shergotty has undergone metasomatic alteration.

EXPERIMENTAL RESULTS. Exp. and analytical techniques are similar to our earlier ones [10,11]. Charges quenched from 1035, 1045, and 1052°C (QFM) consisted of ~50% glass, subequal amounts of CPX (aug. zoned to ferropig.) and PL, and minor Ti-mt. The composition of glass from the 1045°C run is Si=50.2; Ti=1.8; Al=9.2; Fe=24.1; Mn=0.60; Mg=1.4; Ca=8.3; Na=1.7; K=0.56; Nd=0.47; Sm=0.22 (wt% oxide). PX compositions from the three runs are shown in Fig. 2, along with PX for which we previously measured D's [10,11], and Shergotty homogeneous cores [12]. In contrast to our earlier study, PX from the present runs spans a large range of Fe/Mg, comparable to that observed in Shergotty [12].

D's for Sm and Nd are plotted against WO in Fig. 3 and mg' in Fig 4. Correlations with WO are in general agreement with those from our previous experiments [11]. Although no corr. with mg' is apparent from Fig. 4, MLR analysis shows a weak negative corr. The lack of a strong corr. with mg' suggests that factors in addition to Fe/Mg are largely responsible for the corr. of pheno/matrix D's with mg' in Fig. 1. Such factors probably include melt comp. and (T,P) of equilibration.

REE PATTERN OF THE SPM. The major result of the present study is that D's for Shergotty zoned PX rims do not differ markedly from those for the homogeneous cores, at least well past initial PL crystallization. (Absence of a Eu anomaly argues against the presence of cumulus plagioclase in Shergotty [12,14].) Hence use of D's measured for the core compositions does not lead to significant errors in calculated melt TE content, even if portions of the zoned rims are cumulus. Thus the present results support the validity of our previous SPM calculated melt compositions.

Those melt REE compositions are shown in Fig. 5. They are based on the bulk Shergotty composition reported by [4], also shown. Two extreme melt compositions are shown. One corresponds to 70% trapped intercumulus liquid (TL), the case where only the homogeneous PX cores are cumulus as proposed by [12], and the other to 30% TL, an extreme lower limit if Eu-based arguments for the absence of cumulus plagioclase are accepted. Isotopically constrained Sm/Nd ratios of the Shergotty SR are shown (at arbitrary absolute levels) for two extremes of proposed crystallization age [4,15]. All permissible values of Sm/Nd_{SPM} are much greater than all permissible values of source Sm/Nd, thereby precluding simple petrogenetic processes, unless bulk Sm/Nd has been altered by metasomatism.

EVIDENCE AGAINST METASOMATISM. Also shown in Fig. 5 is the SPM REE composition calculated by [3]. Sm and Nd values were obtained simply by dividing the abundances in a very primitive augite [2] by D's previously reported by us [11]. This calculation assumes that the augite is uncontaminated cumulus material, unaltered since crystallization. Excellent agreement between those mineral-based Sm and Nd values and the ones we obtained from the bulk REE content for the homogeneous cumulate case (Fig. 5, TL=.7) suggests two possibilities: (1) If the cumulates were homogeneous then neither primitive augite nor bulk sample were affected by metasomatic alteration of Sm and Nd. (2) If the cumulates were zoned (TL<.7), then Sm, Nd, and Nd/Sm of the bulk sample were increased by metasomatism, relative to primitive augite, and agreement for TL=.7 is fortuitous. In light of experimental and petrographic arguments [12], we regard the former as much more likely. Other elements in the SPM pattern of [3] were scaled from a less primitive PX. Lack of agreement with our TL=.7 pattern (Fig. 5) may indicate selective metasomatism of REE other than Sm and Nd (unlikely), REE evolution prior to crystallization of the more evolved PX (most likely), or problems with the scaling procedure.

CONCLUSIONS. (1) Sm and Nd D's for Shergotty zoned augite rims do not differ markedly from those for magnesian cores of similar WO. (2) Factors in addition to PX Fe/Mg are responsible for the apparent correlation with pheno/matrix D's. (3) Similarity of D's for rims and cores supports our previous estimate of the REE content of the Shergotty parent melt. (4) Agreement between SPM Sm and Nd contents calculated from mineral separates and from bulk sample argues against metasomatic alteration.

References: [1] Laul (1986) The Shergotty Consortium and SNC Meteorites: An Overview. GCA, in press. [2] Jagoutz and Wanke (1986) Sr and Nd isotopic systematics of Shergotty Meteorite. GCA, in press. [3] Laul et al. (1986) Chemical Systematics of the Shergotty Meteorite and the Composition of its Parent Body (Mars). GCA, in press. [4] Shih et al. (1982) GCA 46, 2323. [5] Jagoutz and Wanke (1985) LPSC XVI, sup. A, 15. [6] Smith et al. (1984) PLPSC 14th, B612. [7] Ma et al. (1982) PLPSC 12th, 1349. [8] Nakamura et al. (1982) GCA 46, 1555. [9] Schnetzler and Philpotts (1970) GCA 34, 331. [10] McKay et al. (1985) PLPSC 16th, 540. [11] McKay et al. (1986) CPX Distribution Coefficients for Shergottites: The REE Content of the Shergotty Melt. GCA, in press. [12] Stolper and McSween (1979) GCA 43, 1475. [13] Paster et al. (1974) GCA 38, 1549. [14] Smith and Hervig (1979) Meteoritics 14, 121. [15] Jones (1985) LPSC XVI, 406.

Fig. 1

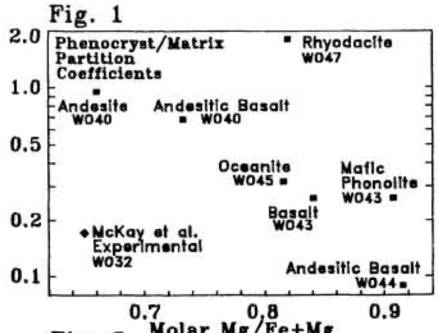

Fig. 2

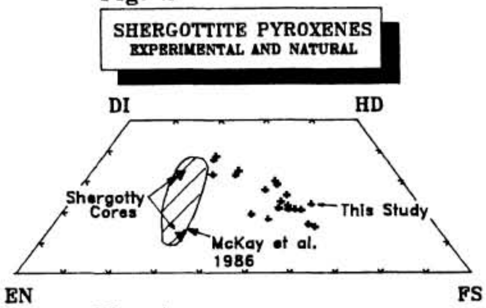

Fig. 3

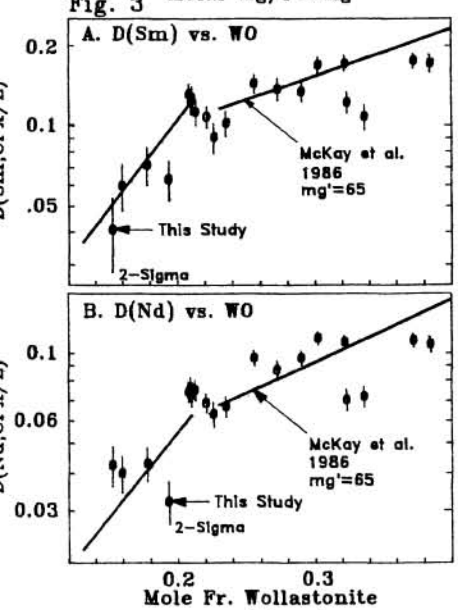

Fig. 4

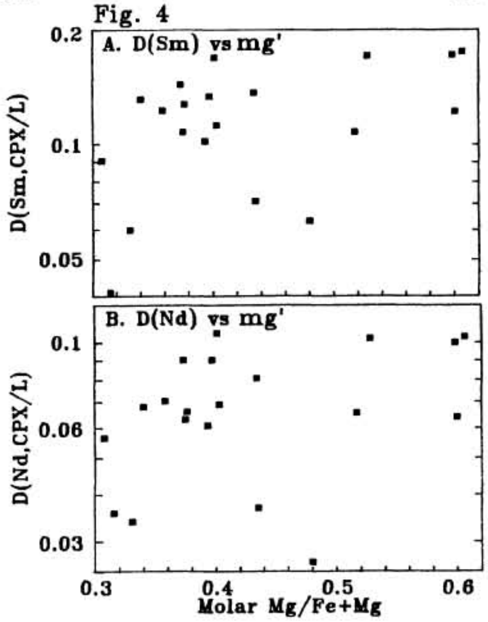

Fig. 5