REDOX EQUILIBRIA IN PALLASITE METEORITES AND THE EUCRITE PARENT BODY (EPB). K. Righter, R.J. Arculus, Department of Geological Sciences, University of Michigan, Ann Arbor, MI 48109 and J. W. Delano, Dept. of Geological Sciences, SUNY-Albany, Albany, NY 12222.

Pallasite meteorites contain olivine, iron-nickel metal and minor troilite, chromite, schreibersite, phosphates and phosphoran olivine. Despite this consistent and simple mineralogy in approximately 50 described pallasites (1,2), the redox character of the pallasites remains unclear. Pallasites are thought to be pieces of the core-mantle boundary of a small differentiated planet (3,4); knowledge of redox equilibria involved in such planetary differentiation and core formation is essential in understanding analogous terrestrial processes. Previous intrinsic oxygen fugacity (IOF) measurements of Salta and Brenham olivine separates (5,6) and thermodynamic calculations involving phosphide-phosphate-metal assemblages (7), yield very different results (Figure 1). The work presented here was undertaken in order to resolve this discrepancy of values.

The IOF of olivine separates from the pallasites Salta, Springwater and Eagle Station was measured between 850^0 and 1150^0C using solid zirconia electrolytes at one atmosphere. The experimental apparatus was a doubly-opposed electrolyte configuration with a $CO-CO_2$ gas-mix bridging atmosphere, which is described in detail elsewhere (8,9,10). Four initial measurements on Salta olivines revealed the importance of grain size (Figure 2). Coarse grained (45-125 μm) olivine samples equilibrated at or above the iron-wustite buffer (IW), while fine grained olivine samples (< 45 μm) equilibrated at or below IW. Those samples started with an oxidized cell memory (log $fO_2 \sim -3$) equilibrated one log unit above IW, whereas those with a reduced cell memory (log $fO_2 \sim -15$) equilibrated one log unit below IW. Greater sample reactivity with finer grain size, and the apparent stability of Salta olivines at or near IW suggested that best results would be attained using fine grained olivine (<45μm) and a reduced cell memory. This procedure was adopted in the next set of measurements.

Olivine separates from Salta, Springwater and Eagle Station were measured in this manner and the results appear in Figure 3. The trend from below to above IW is matched by differences in each pallasite's composition. Salta, the most reduced sample, is correspondingly Fa-poor and X_{Ni} (in metal)-poor; Springwater has a similar metal composition, but Fa-rich olivine; Eagle Station , the most oxidized sample, is correspondingly Fa-rich, and X_{Ni}-rich. These consistent results provide better constraints on the redox character of the main group pallasite parent body, and offer a first look at the redox character of the 'Eagle Station Trio' parent body.

Electron microbeam characterization (SEM and EMPA) of the starting materials and run products from these experiments has shown that olivine is the only phase present. Single phase IOF measurements involve such equilibria as Fe^{2+}/Fe^{3+} and/or vacancies. Such redox equilibria will not be dominant in the parent body, but will be set by other, more robust, redox equilibria, such as:

$$3Mg_2SiO_4 + 4Fe_3P + 8O_2 = 2Mg_3(PO_4)_2 + 3Fe_2SiO_4 + 6Fe$$

or

$$Fe_2SiO_4 = 2Fe + Si_{(ss\ in\ Fe)} + 2O_2.$$

Although thermodynamic data for some of these phases is limited, these equilibria can set additional constraints on the oxidation state of the pallasites, and agree well with our experimental results.

Eucrites, diogenites, howardites, mesosiderites, pallasites and IIIAB iron meteorites are all thought to be pieces of the same parent body or bodies (referred to as the Eucrite Parent Body, or EPB), on the basis of petrologic, geochemical and isotopic characteristics (11-20). IOF measurements of nearly all meteoritic components of

FIGURE 1

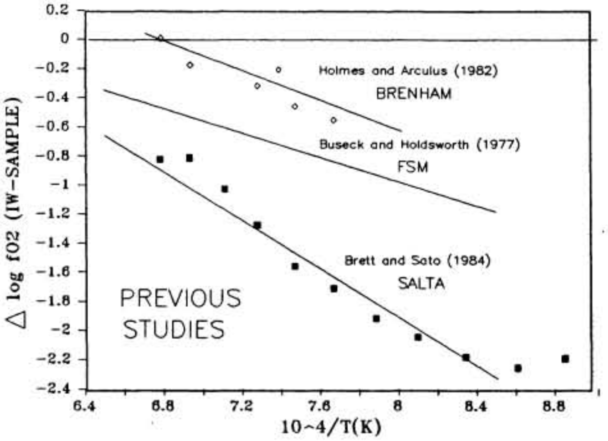


FIGURE 2

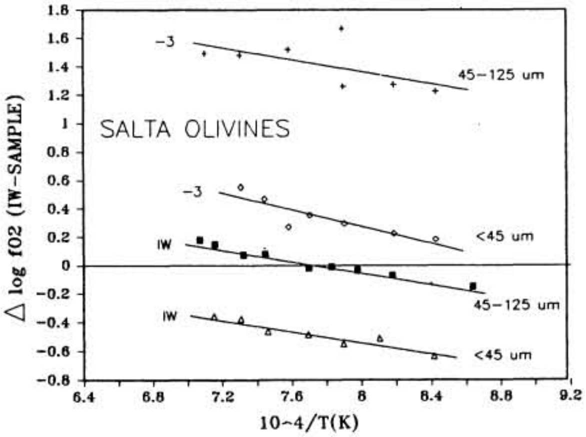


FIGURE 3

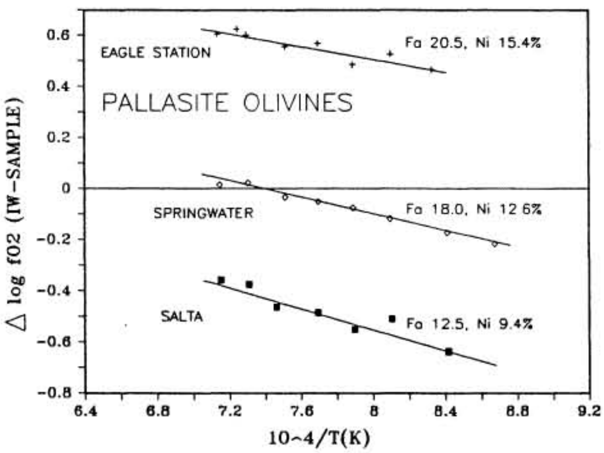
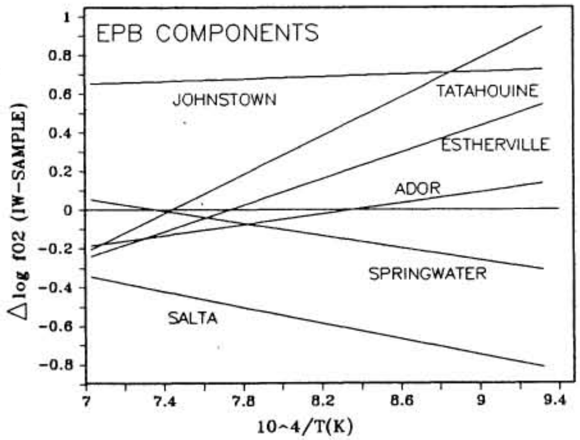


FIGURE 4



this planetary body(ies) have been completed; results from Angra Dos Reis (21), diogenite and mesosiderite clasts (22), and pallasite olivines (this study) indicate that the oxidation state of this planetary body(ies) was within one log unit of the IW buffer (Figure 4). Calculations of eucrite source compositions (or EPB mantle composition), however, result in an FeO-rich source (12,16,17). Such a mantle would have olivine of greater Fa content (~Fo65) than pallasite olivines and hence are in stark contrast to our olivine IOF measurements at or below IW. In addition, the compositions of chromian spinel in EPB components are variable (23). Such differences in fO_2-T-X relations suggest large redox gradients in the EPB.

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