Division 6 - Lincoln Laboratory
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

SUBJECT: GRAPHICAL SUMMARY OF CORE DATA IN THE $MgO-Fe_2O_3-MnO$ SYSTEM

To: David R. Brown

From: John B. Goodenough

Date: January 25, 1954

Abstract: A graphical summary of some of the magnetic data which were collected during 1953 on the $MgO-Fe_2O_3-MnO$ System is presented.

Introduction

In the graphs which follow, the compositions plotted are "as blended" mixtures and do not represent the final chemical compositions. In Figure 1 are shown some of the compositions whose microstructure has been examined. Typical photographs of the observed microstructures are shown in Figure 2. In the magnesium-rich samples, a precipitate of MgO formed along the grain boundaries: in samples with a large magnesium excess, the spinel crystals formed in the MgO matrix. The α-Fe_2O_3 precipitate formed as sheets which usually penetrated from the outer surface of the core, or from inner surfaces about large flaws. The precipitate which forms in the manganese-rich portion of the diagram is believed to be tetragonal $2MO \cdot MnO_2$ or tetragonal $MO \cdot Mn_2O_3$, where M is a bivalent cation. Which description is used will depend upon whether Mn^{4+} ions are present in Mn_3O_4. In either case the precipitation mechanism is believed to be essentially that presented in M-2473.[1] The regular lamellations in definite crystallographic planes appear to be those predicted by that mechanism.

A steep drop in squareness ratio, a reduction in magnetic induction, and an increase in coercivity occurs for those samples in which precipitation has occurred. Part of the decrease in B_s [~30 Oe] is due to a failure to saturate the core at 30 Oe applied field when heavy precipitation, which causes low μ gaps in the flux path, has occurred. The saturation (~30 Oe) coercive-force values are correspondingly in error in these regions.

The low R_s values in the middle of the good-squareness region are not yet understood. More cores of these compositions are being prepared to check whether this is a true low-squareness region. Measurements of the anisotropy constant are also planned. Low values of K in this region could cause a collapse in loop squareness.

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1. J. B. Goodenough, "B-H Loop Squareness in the Magnesium-Manganese Ferrites," Lincoln Laboratory Memorandum M-2473, October 22, 1954.

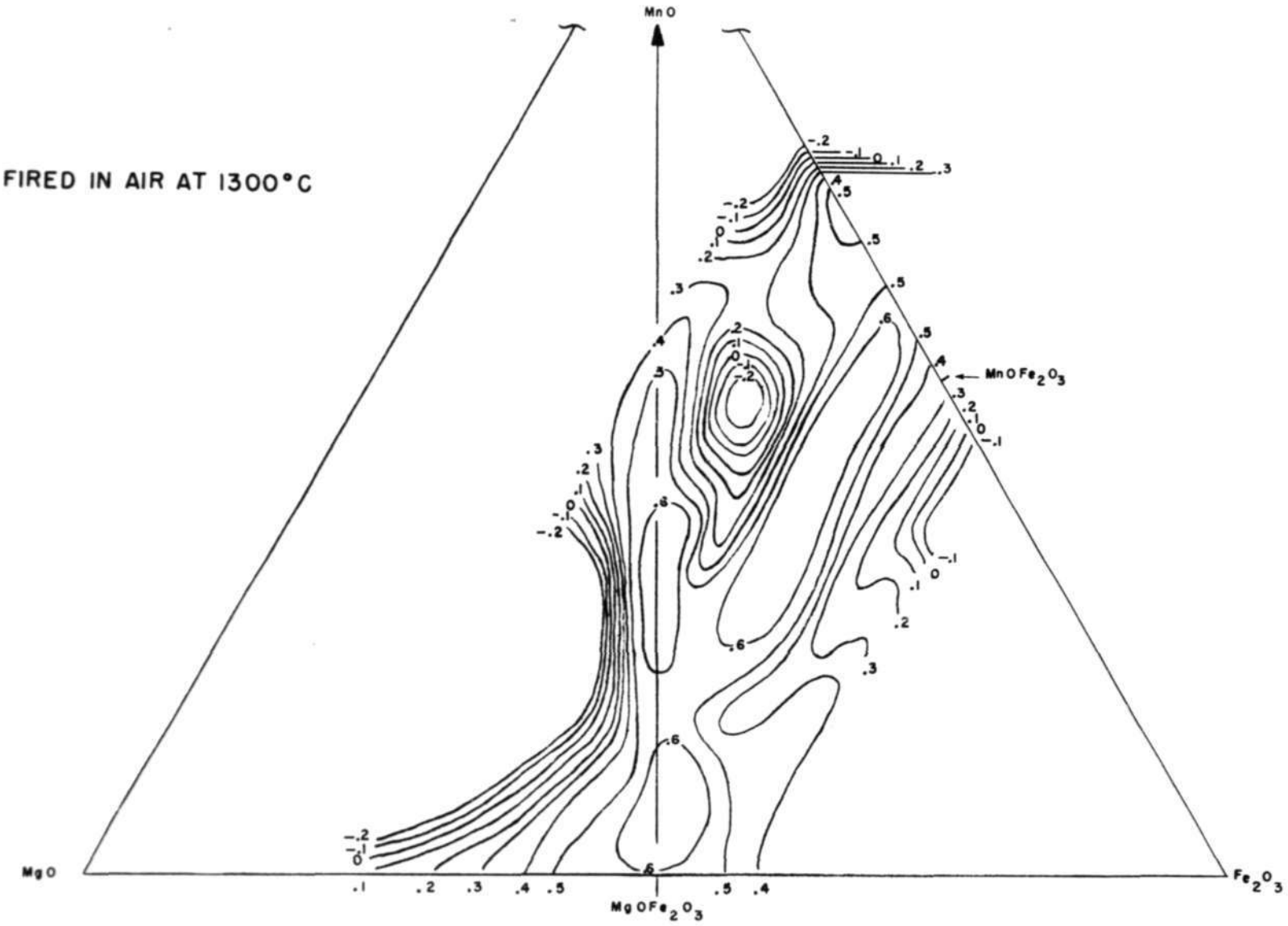
Contours of Equal Squareness Ratio

$R_s = B_{Hm}/B_{-Hm/2}$

A-57616
A-57618
A-57619
A-57617
A-57620
A-57612
A-57613
A-57614

A-57616

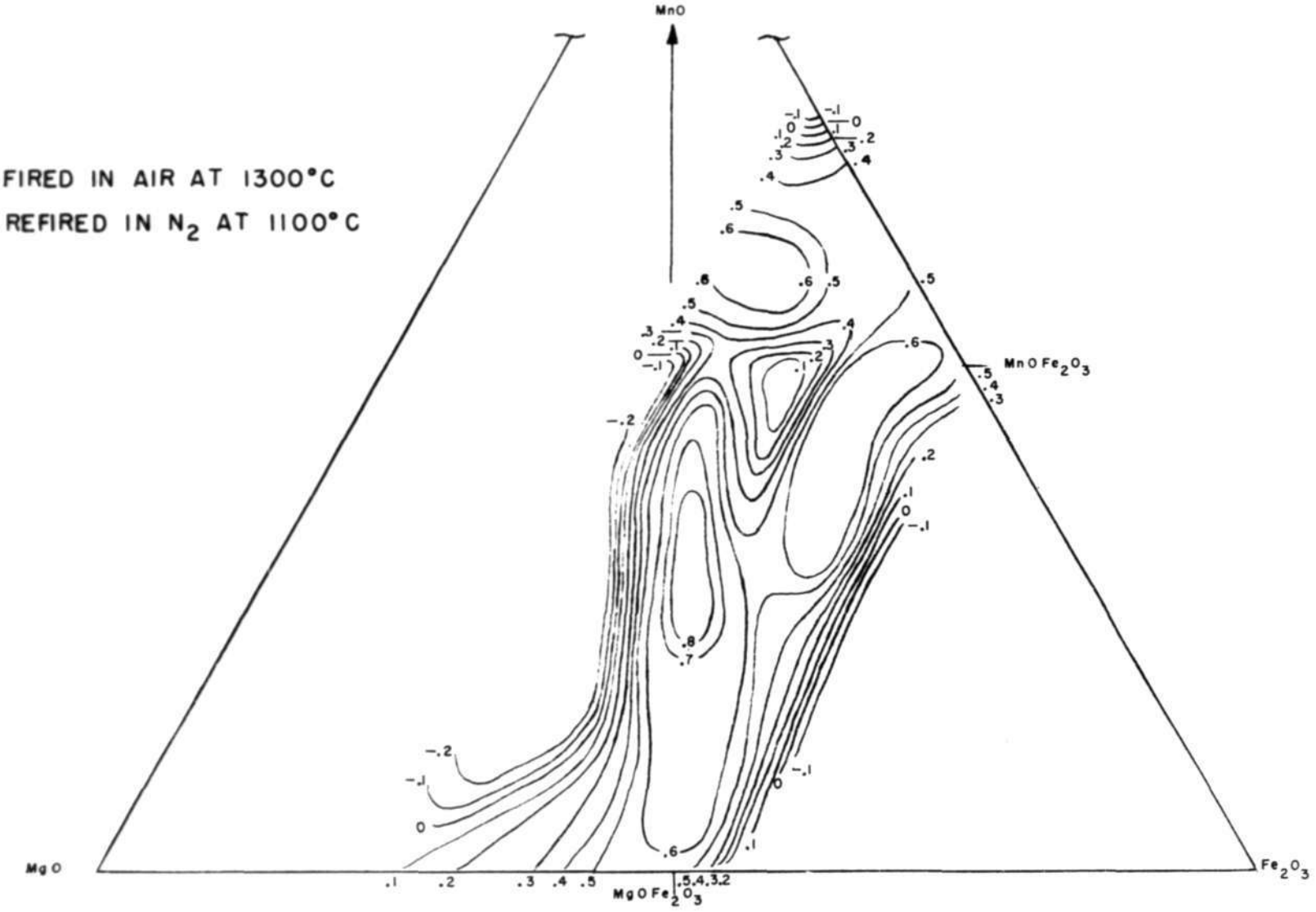
FIRED IN AIR AT 1300°C



A-57618

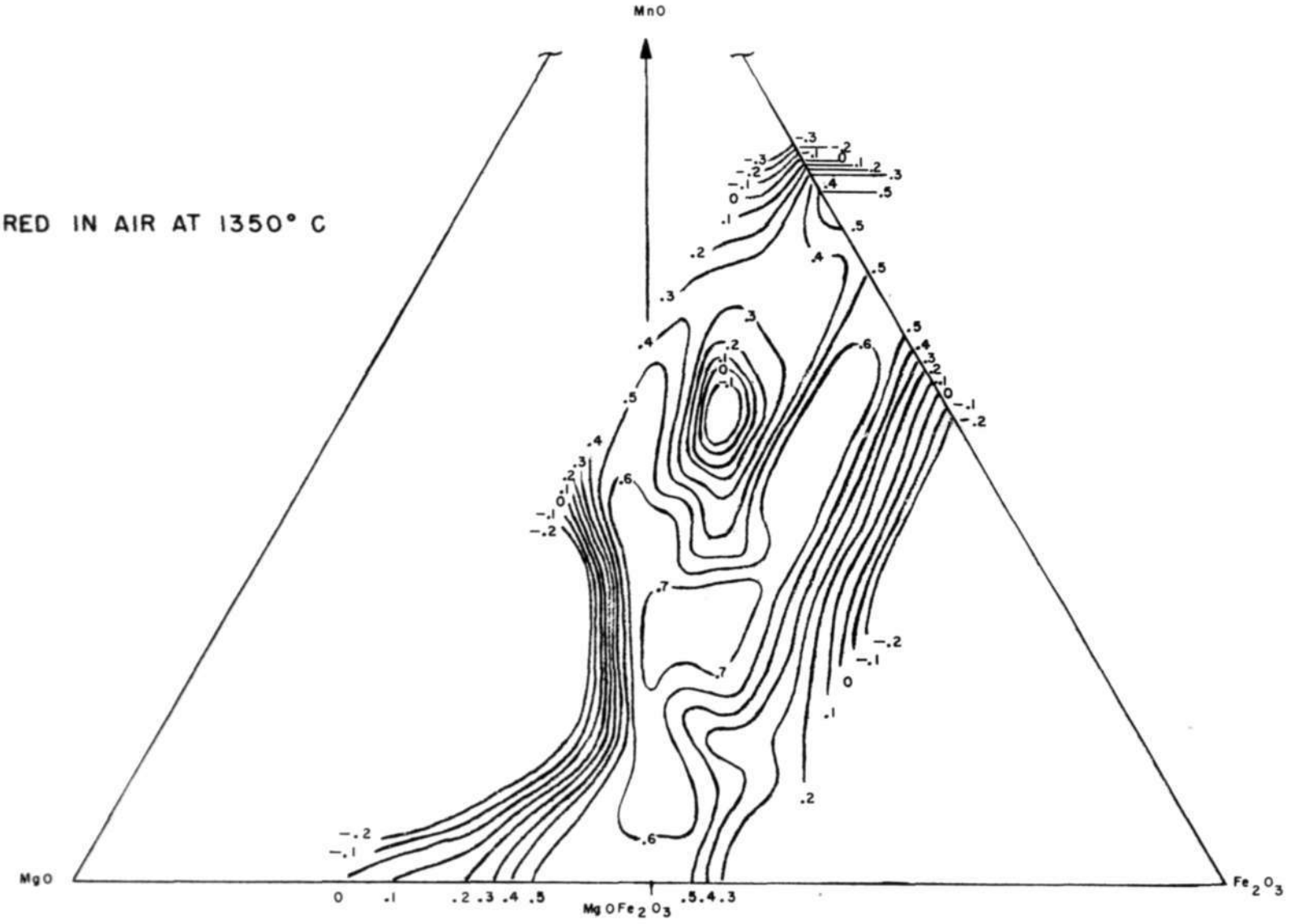
FIRED IN AIR AT 1300°C

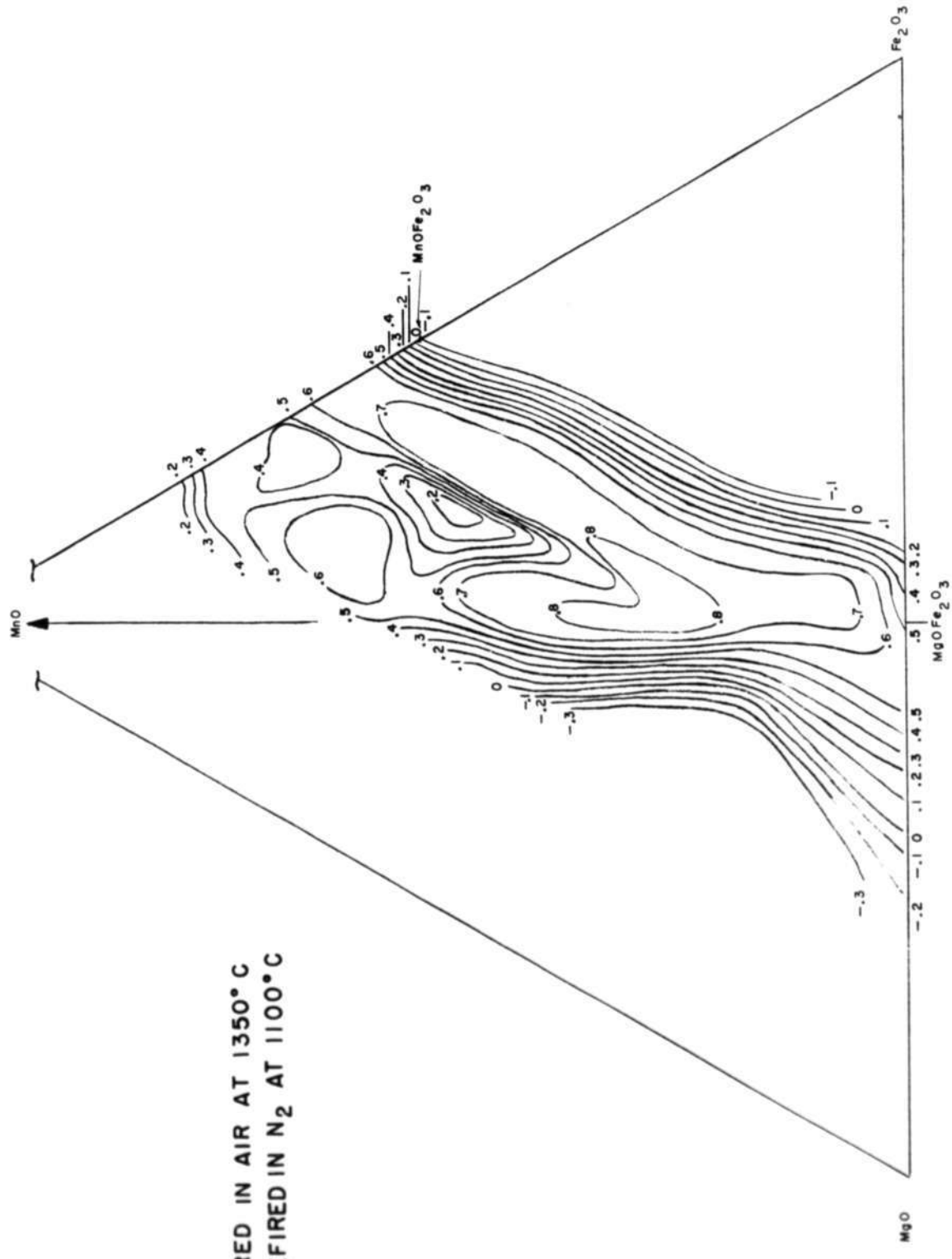
REFIRED IN N_2 AT 1100°C



A-57619

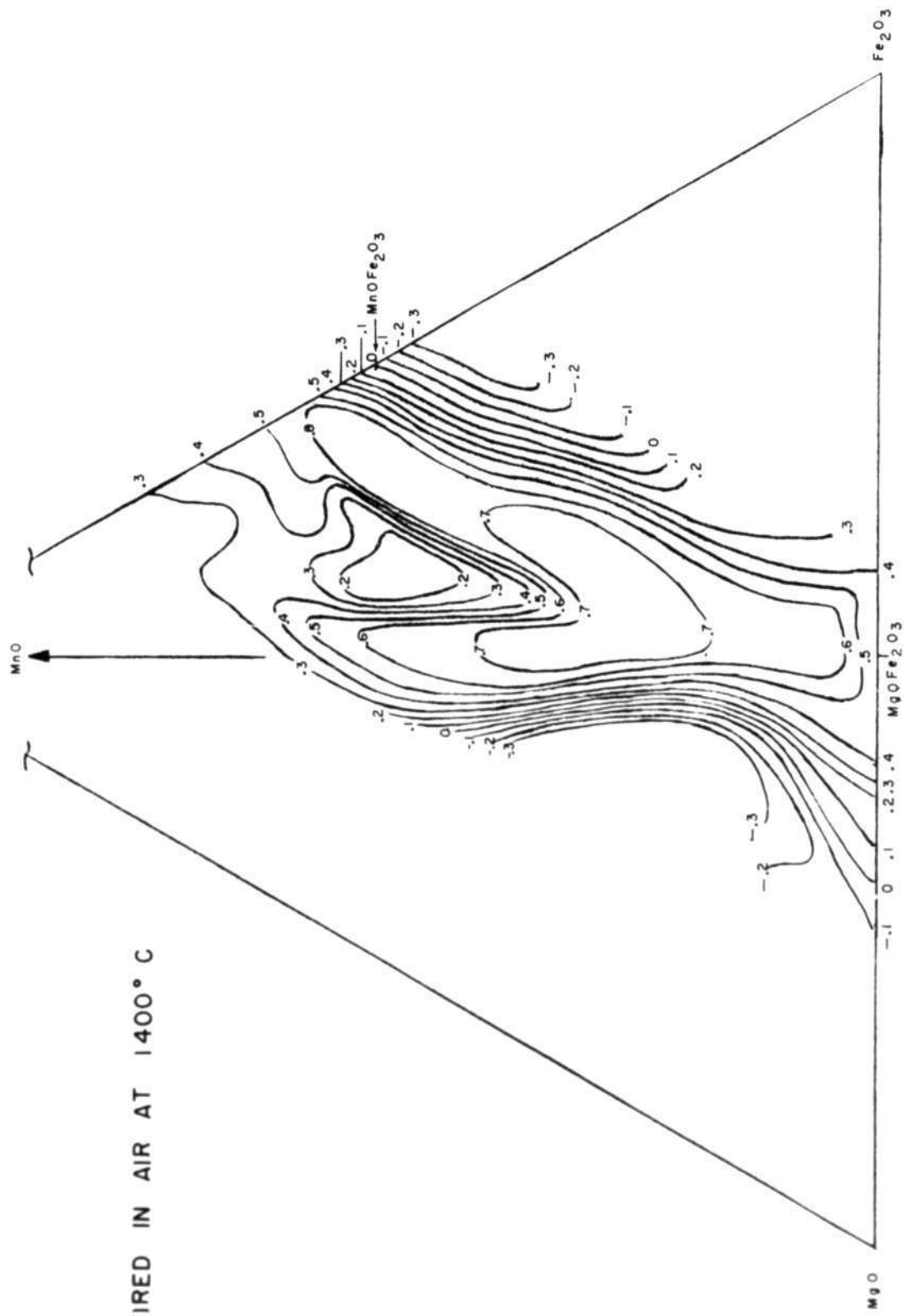
FIRED IN AIR AT 1350° C





FIRED IN AIR AT 1350° C
REFIRED IN N_2 AT 1100° C

A-57617

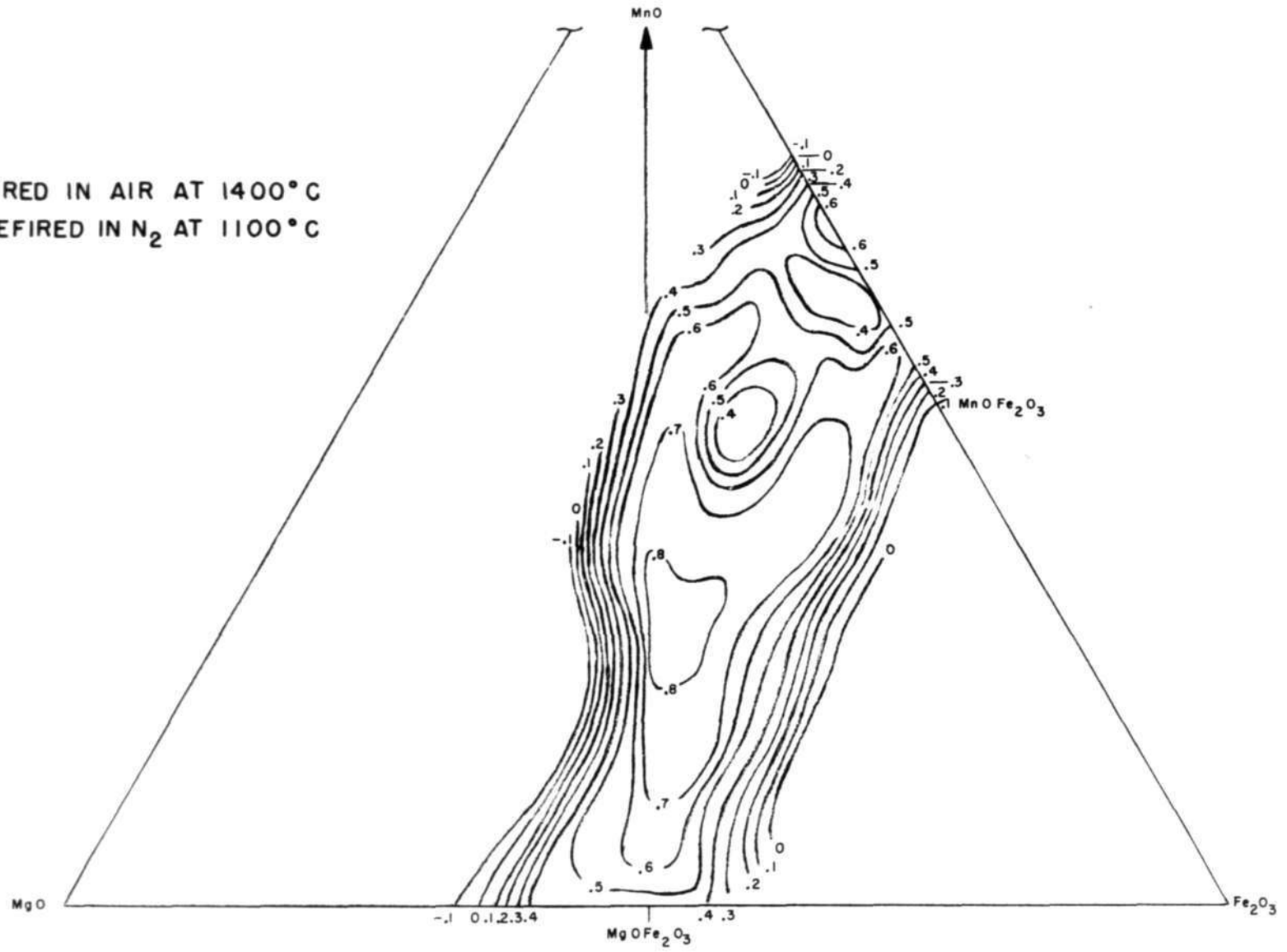


FIRED IN AIR AT 1400° C

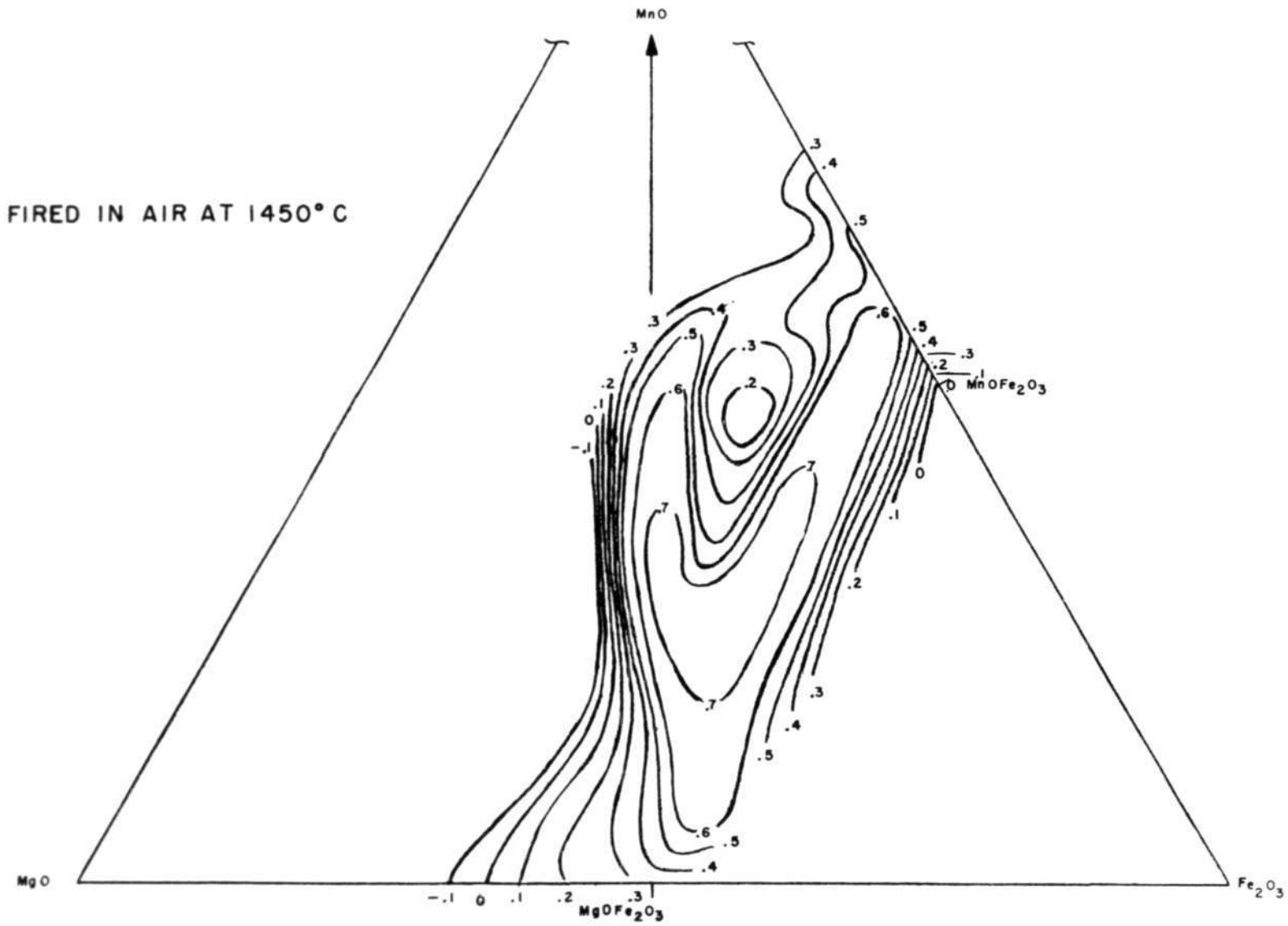
A-57620

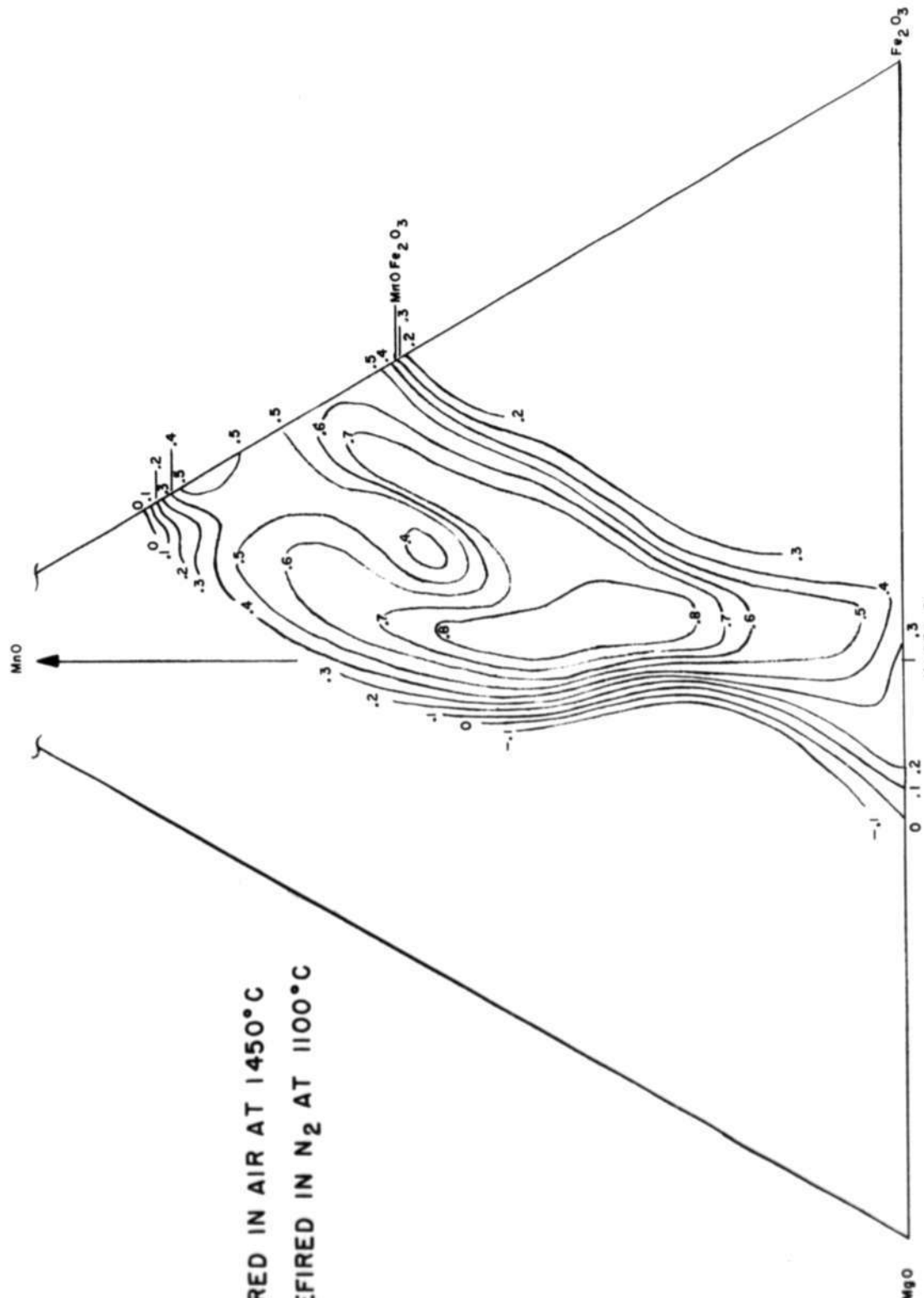
A-57612

FIRED IN AIR AT 1400°C
REFIRED IN N_2 AT 1100°C



A-57613





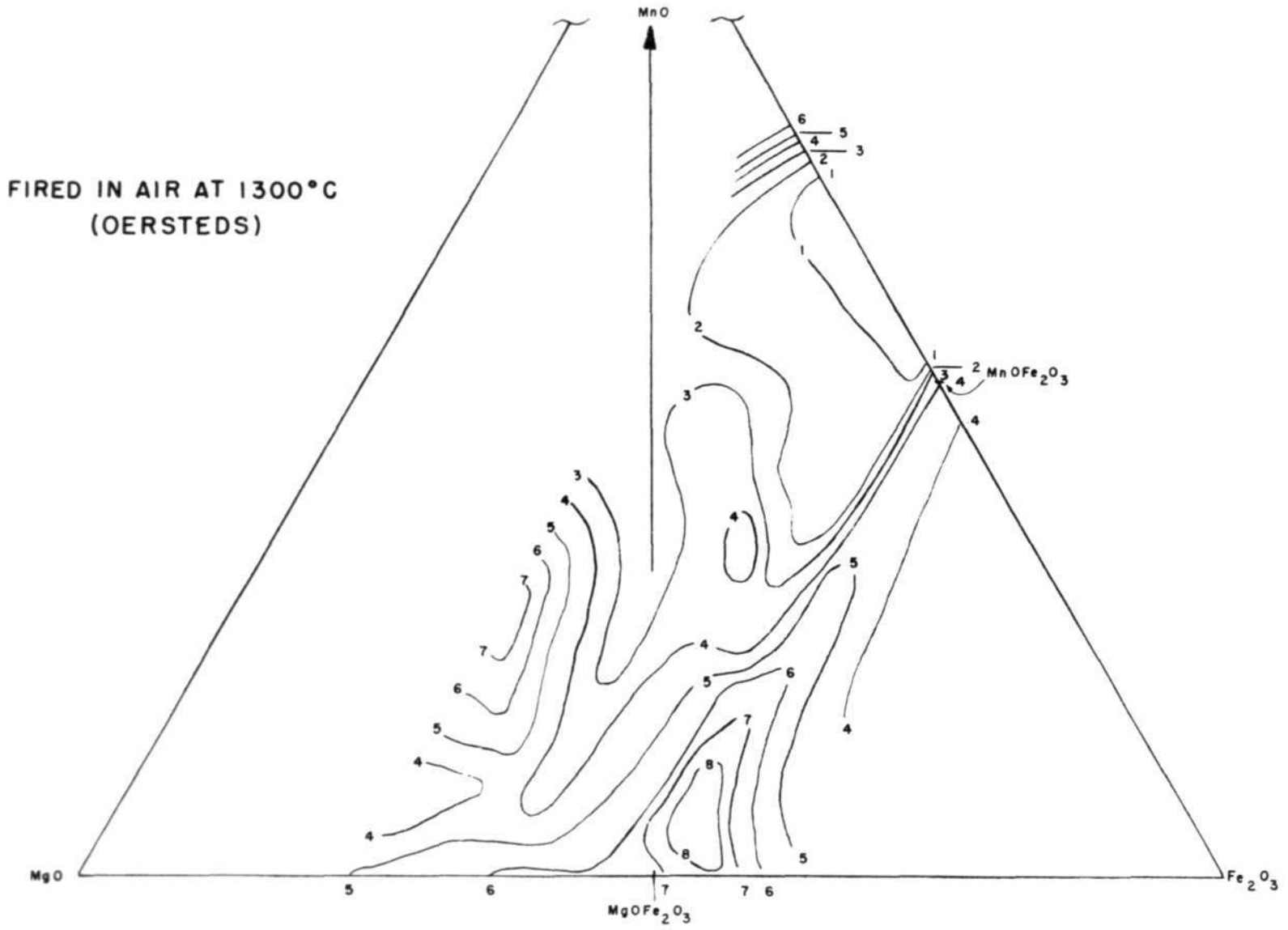
FIRED IN AIR AT 1450°C
REFIRED IN N_2 AT 1100°C

A-57614

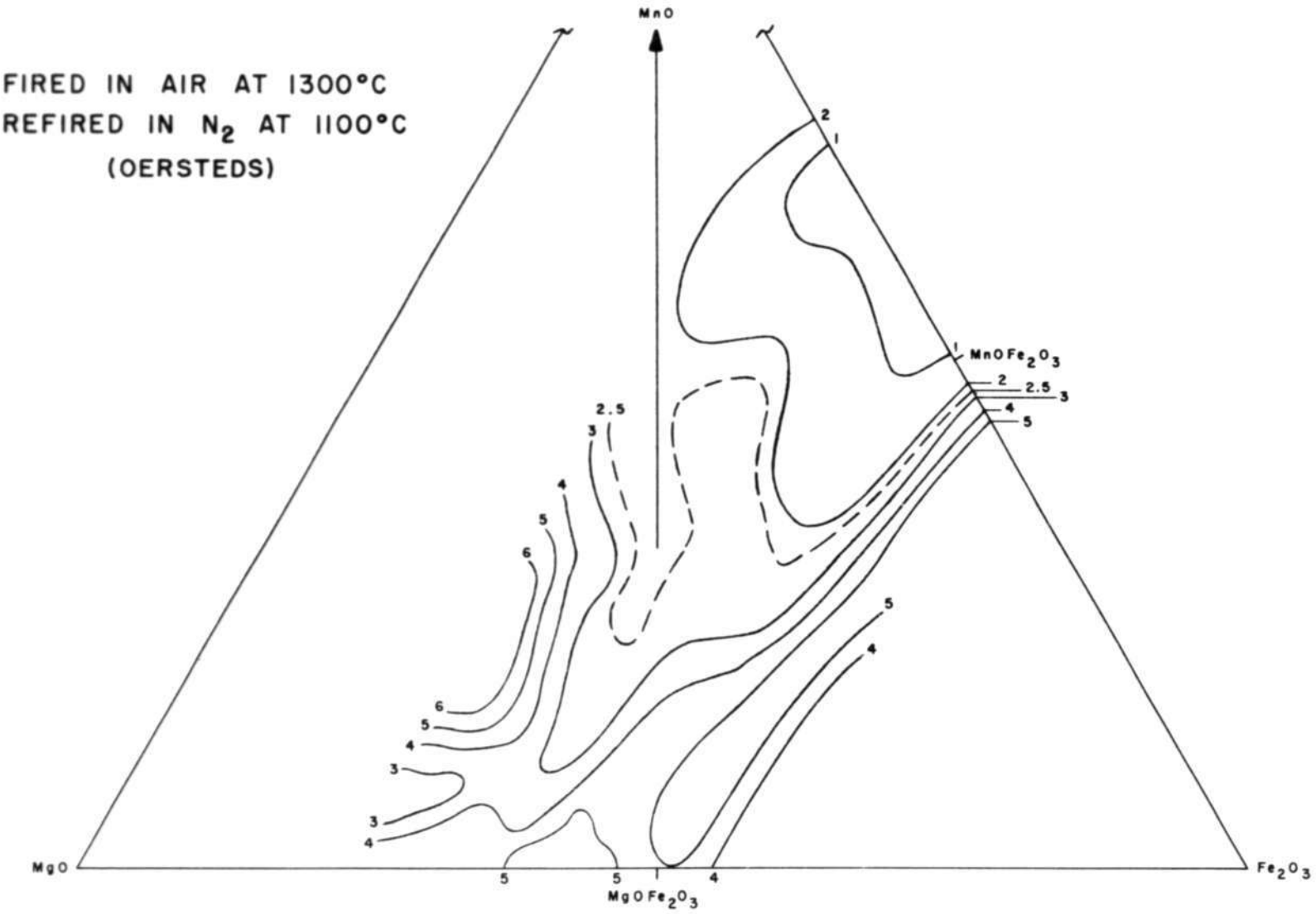
Contours of Equal Coercivity at Saturation (30 Oe)

A-57615
A-57625
A-57626
A-57627
A-57609
A-57607
A-57606
A-57608

A-57615



A-57625



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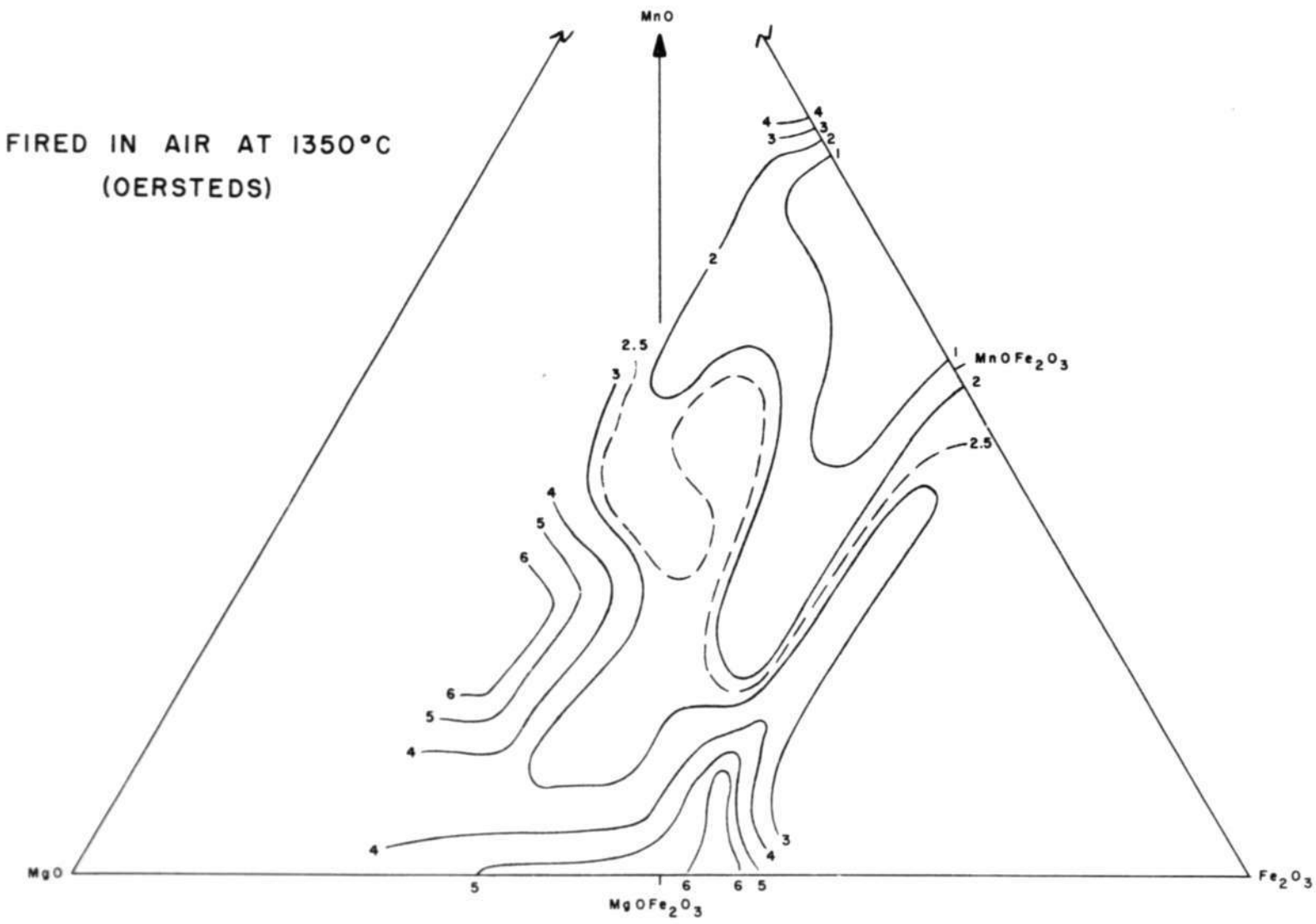

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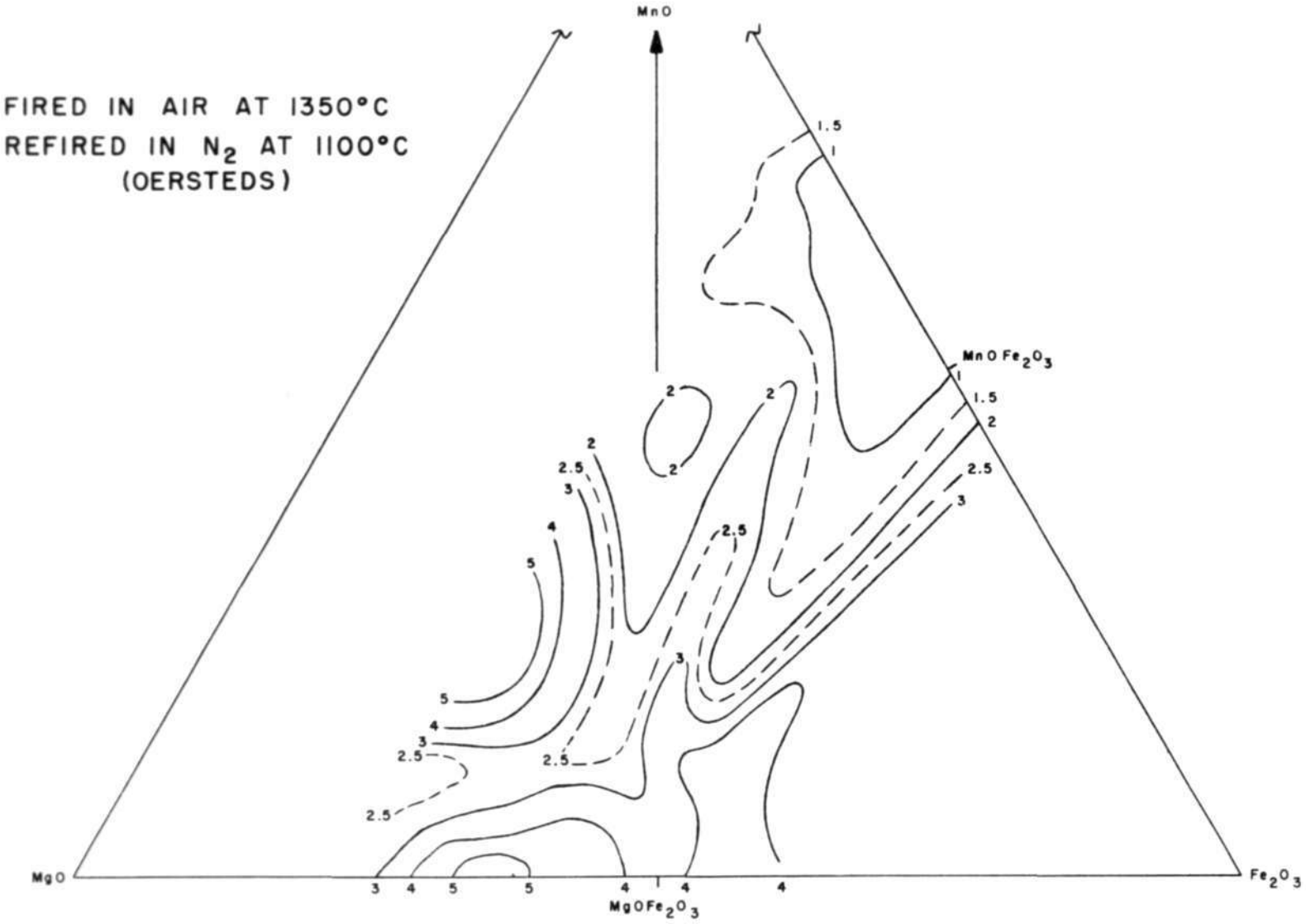

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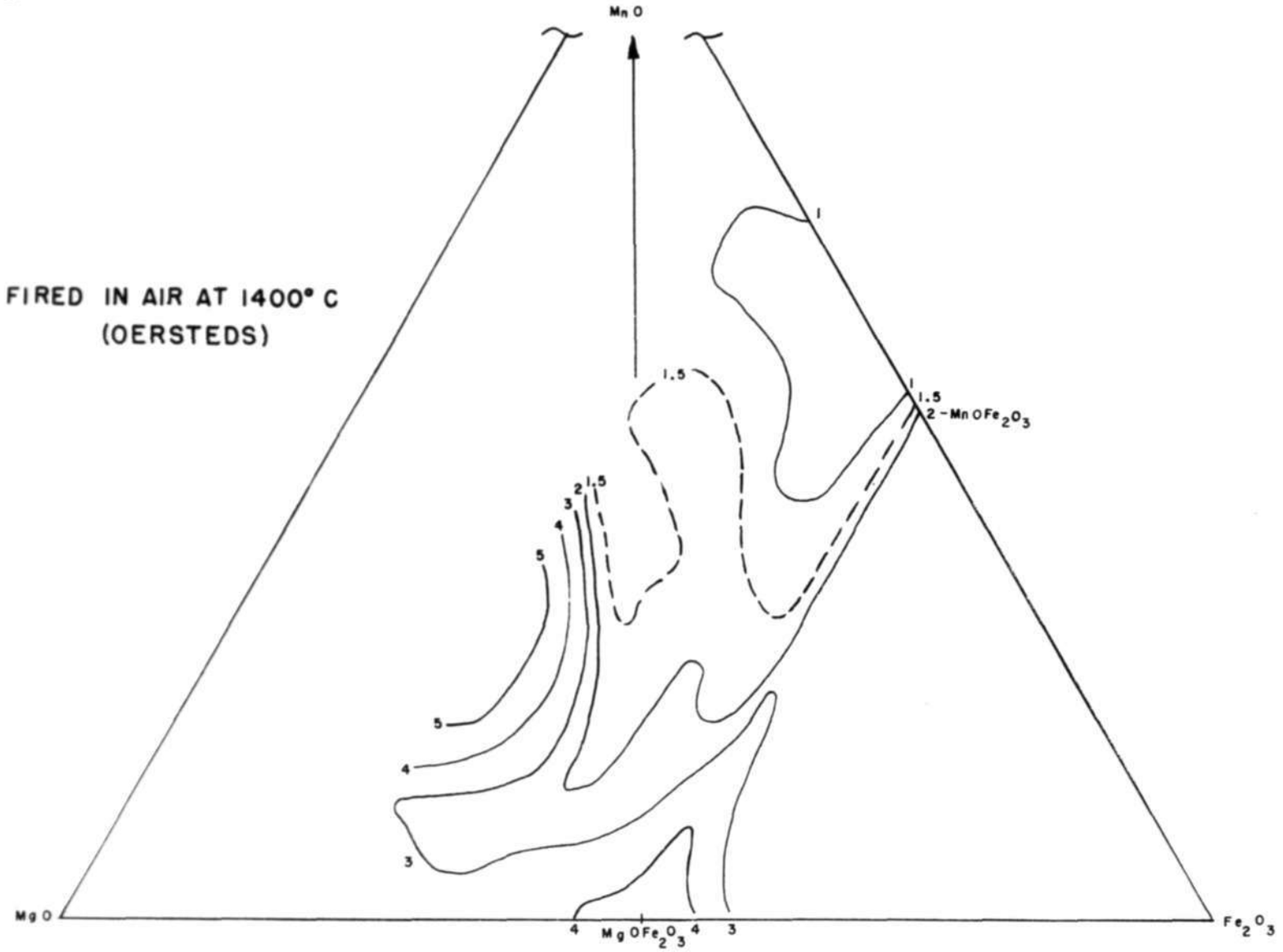

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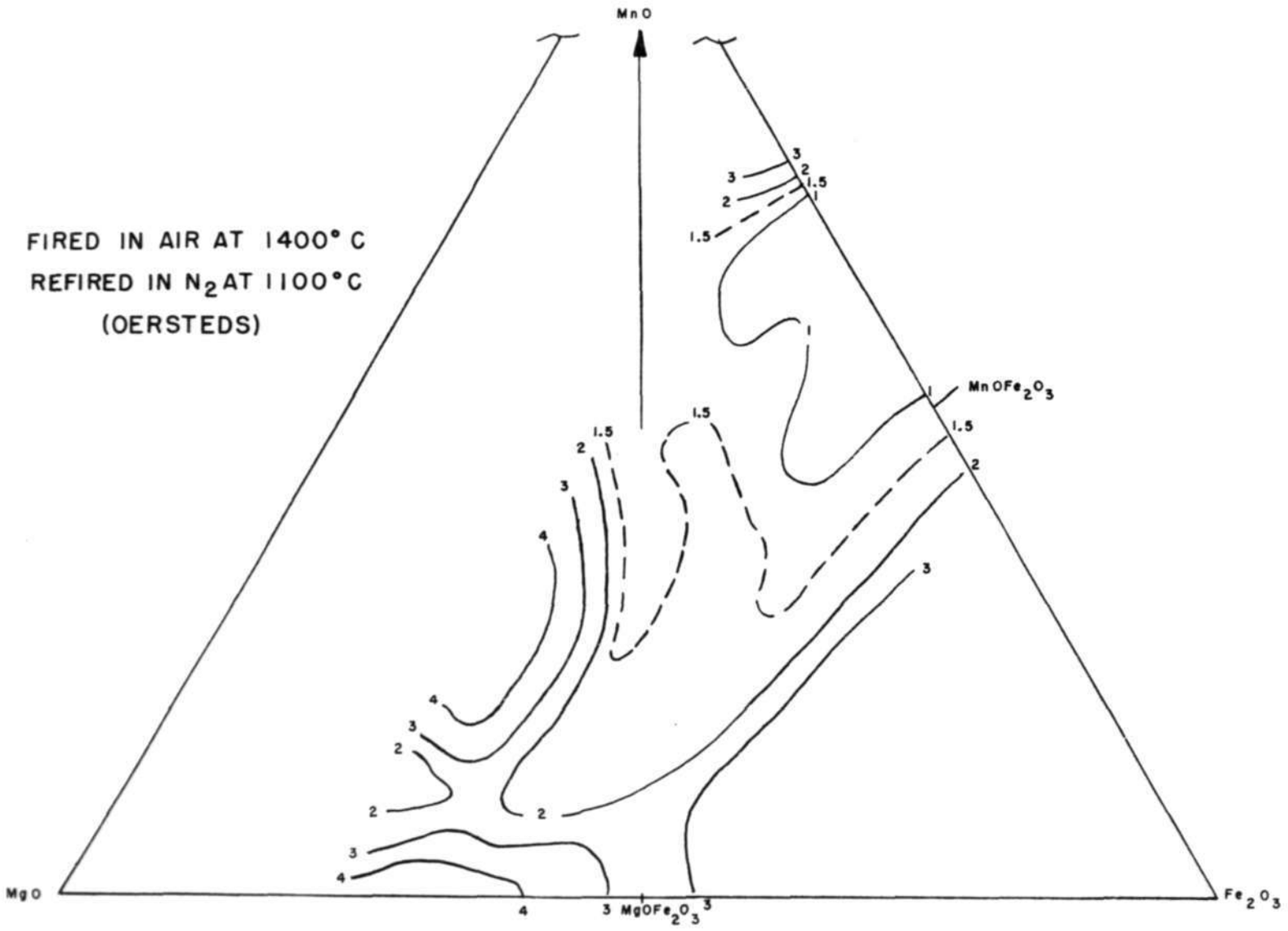

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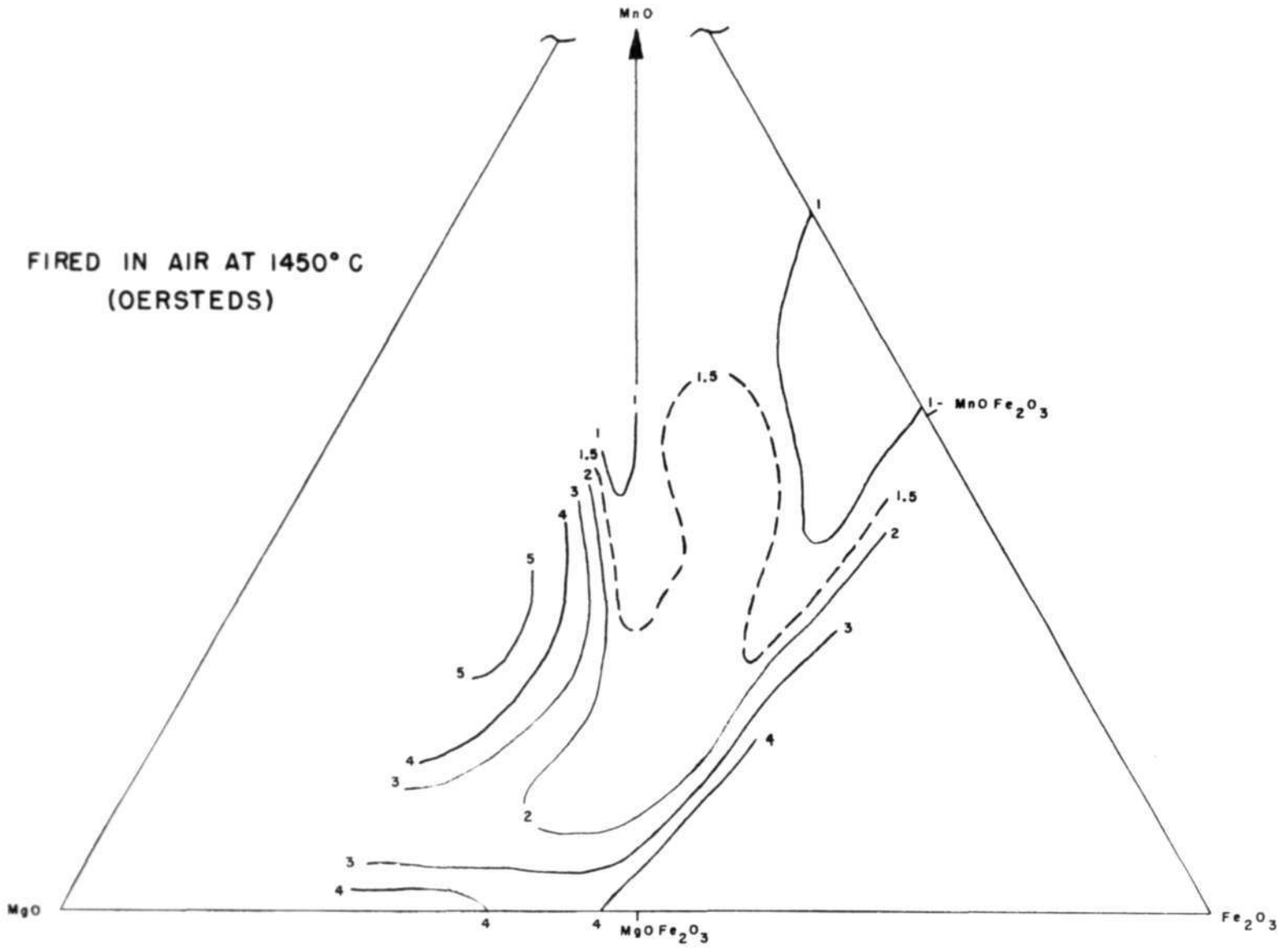

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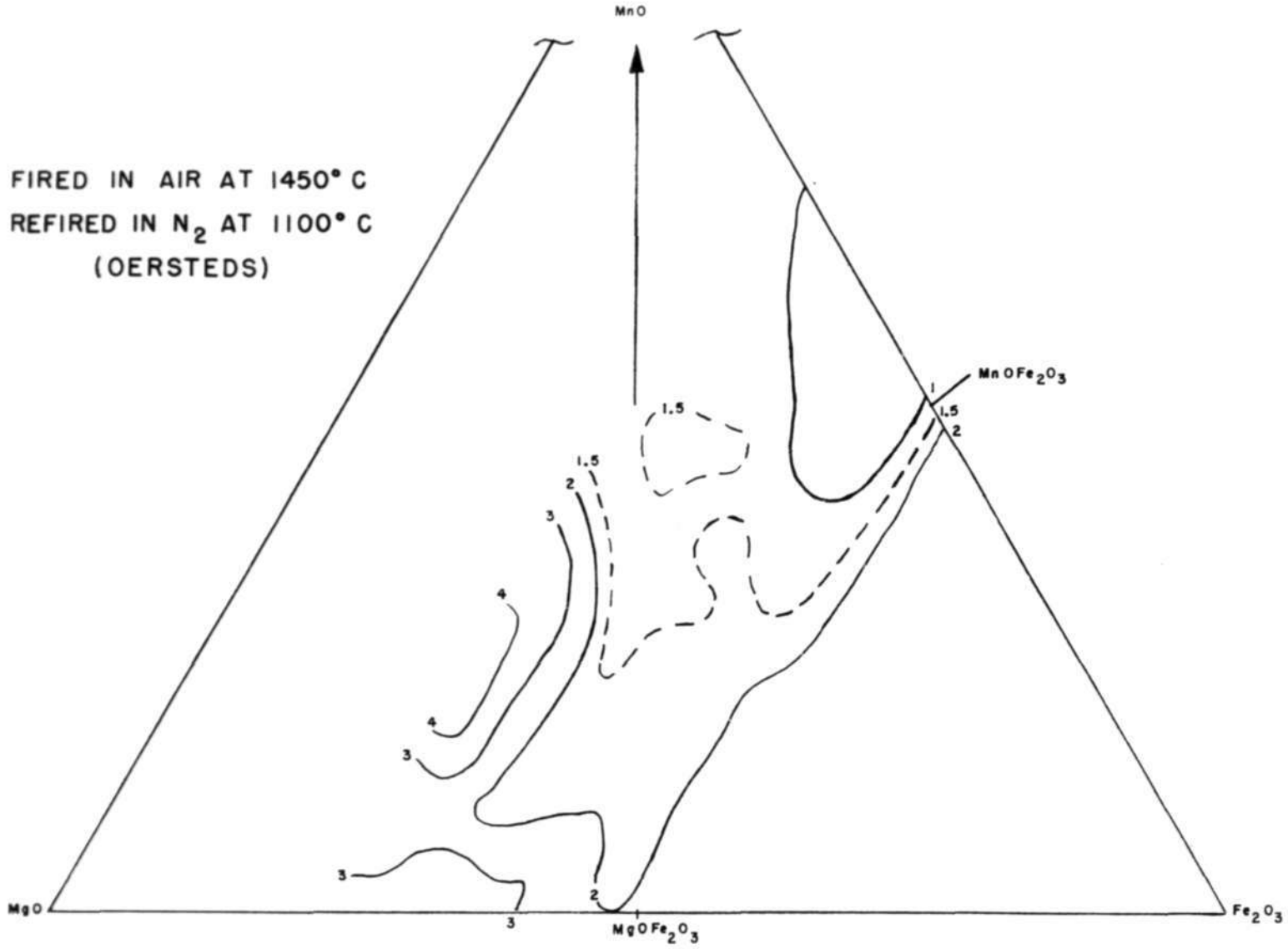
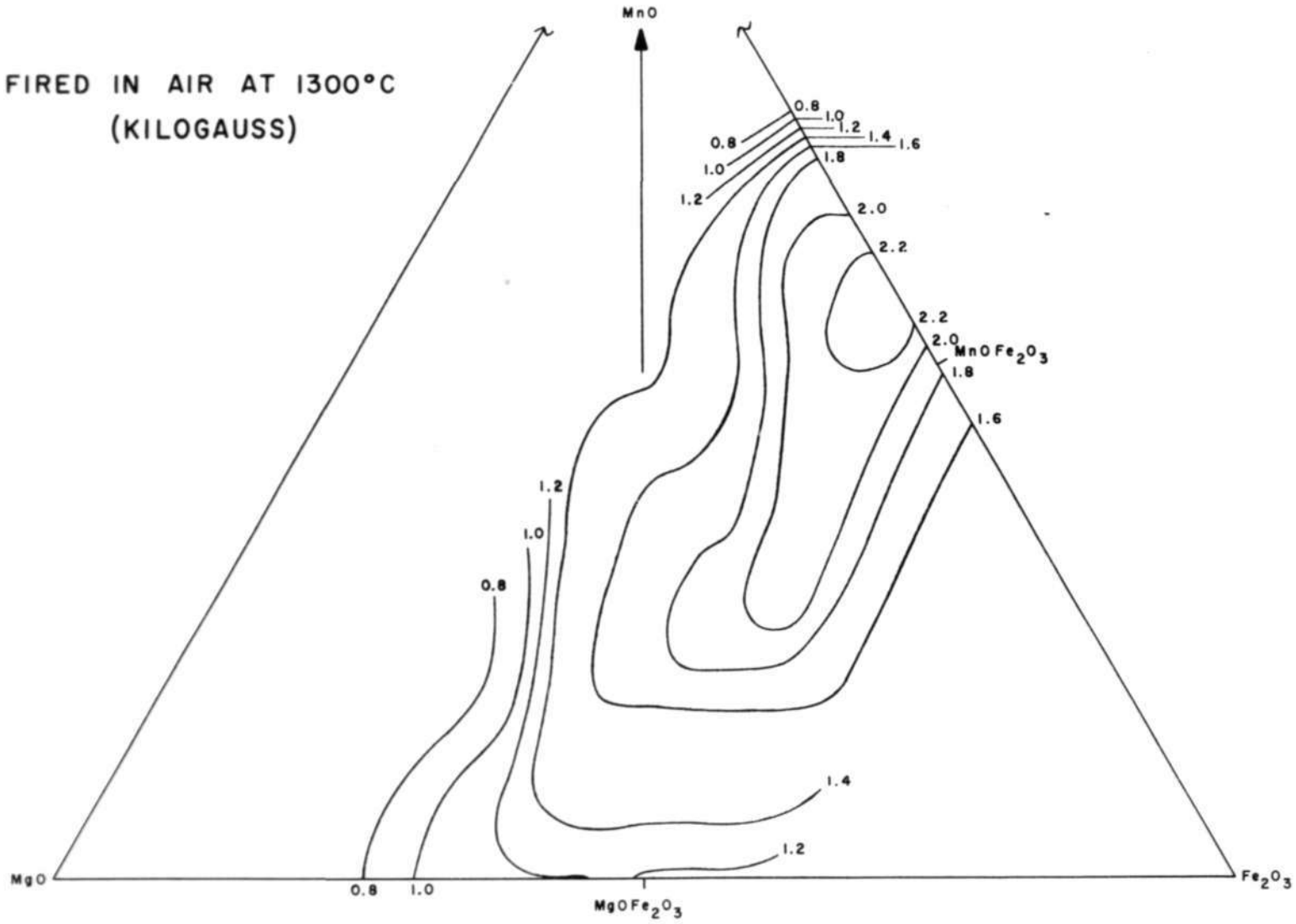


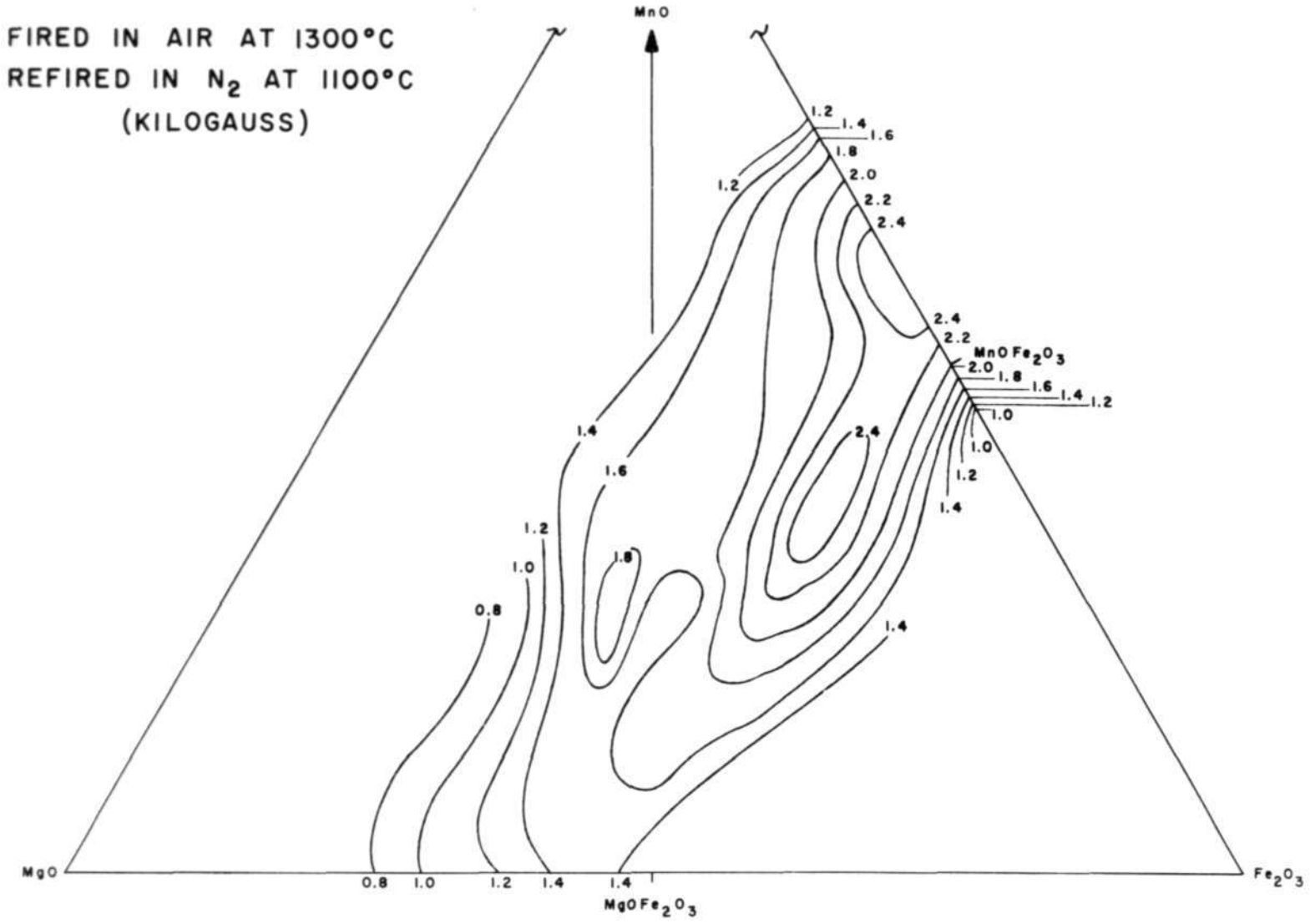
Contours of Equal Induction at Saturation (30 Oe)

A-57622
A-57621
A-57623
A-57624
A-57611
A-57604
A-57610
A-57605

A-57622



A-57621



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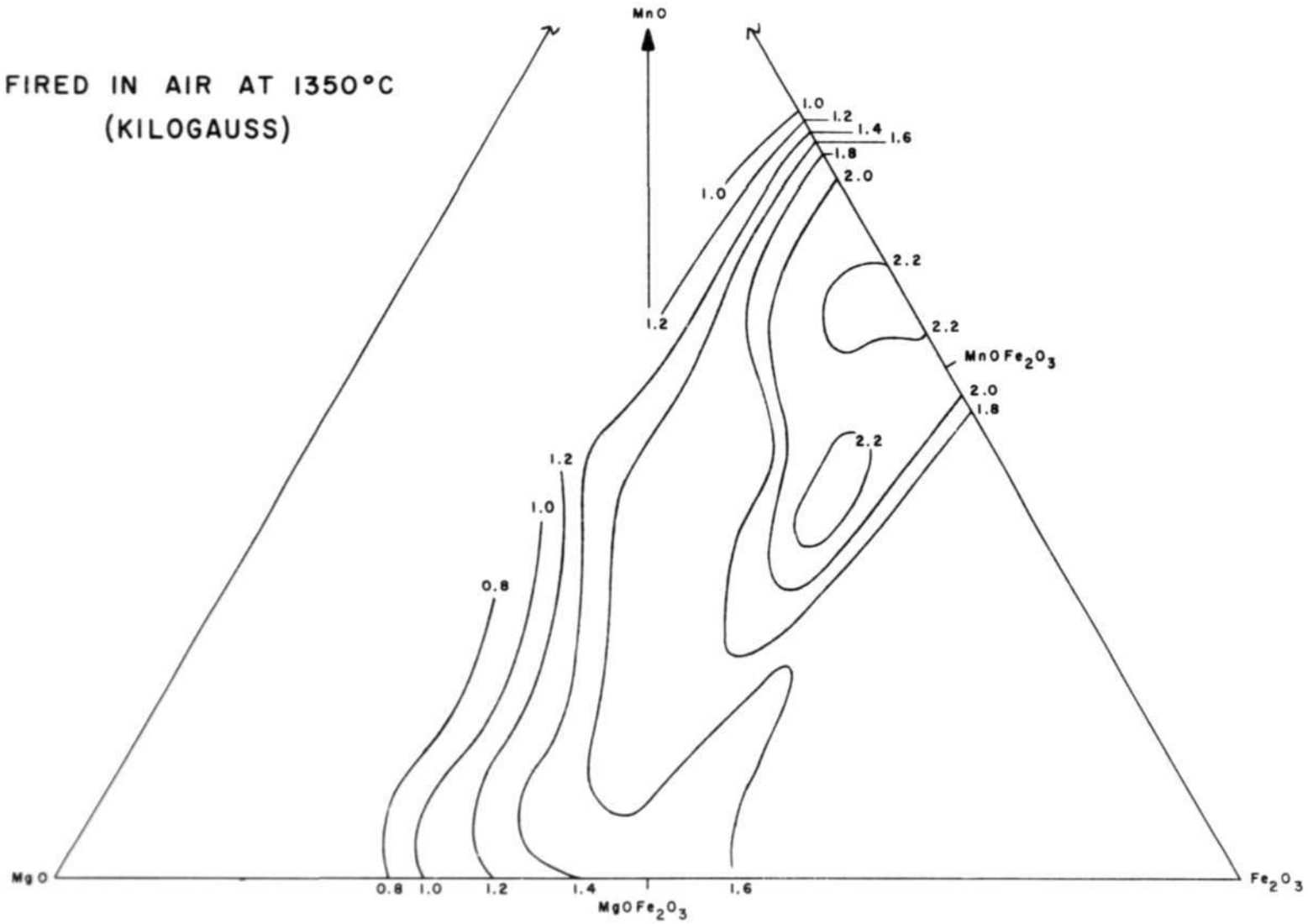
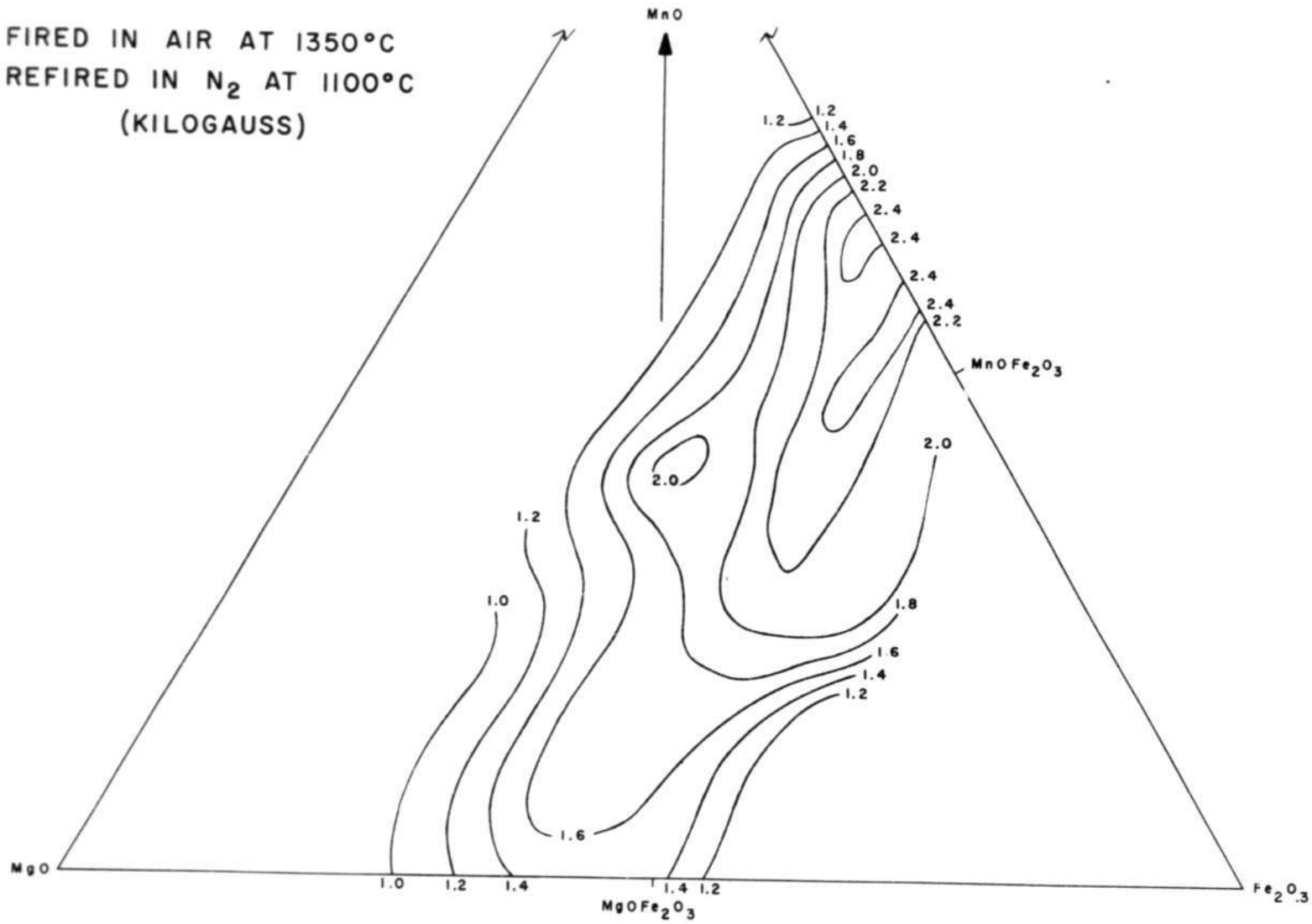
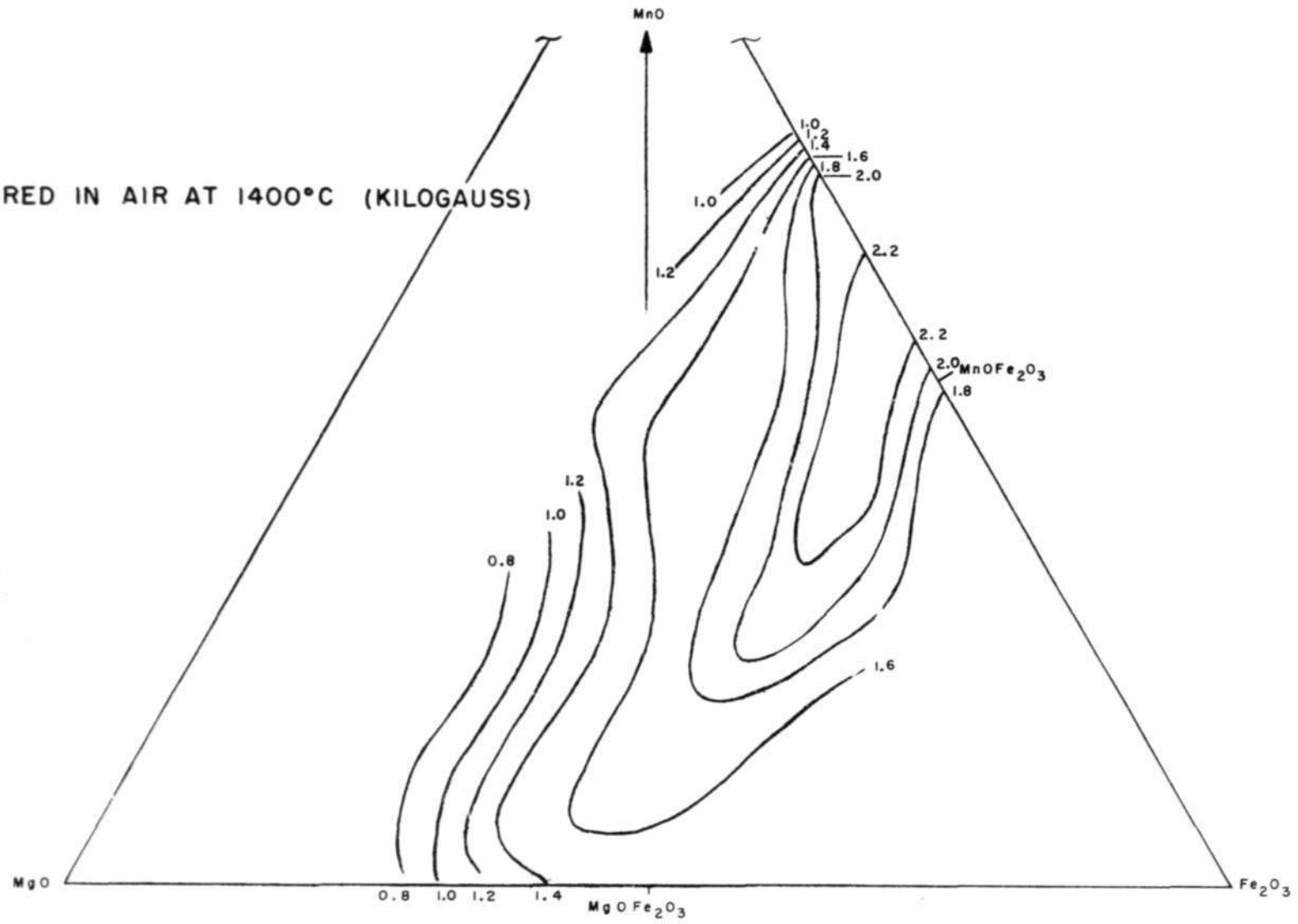


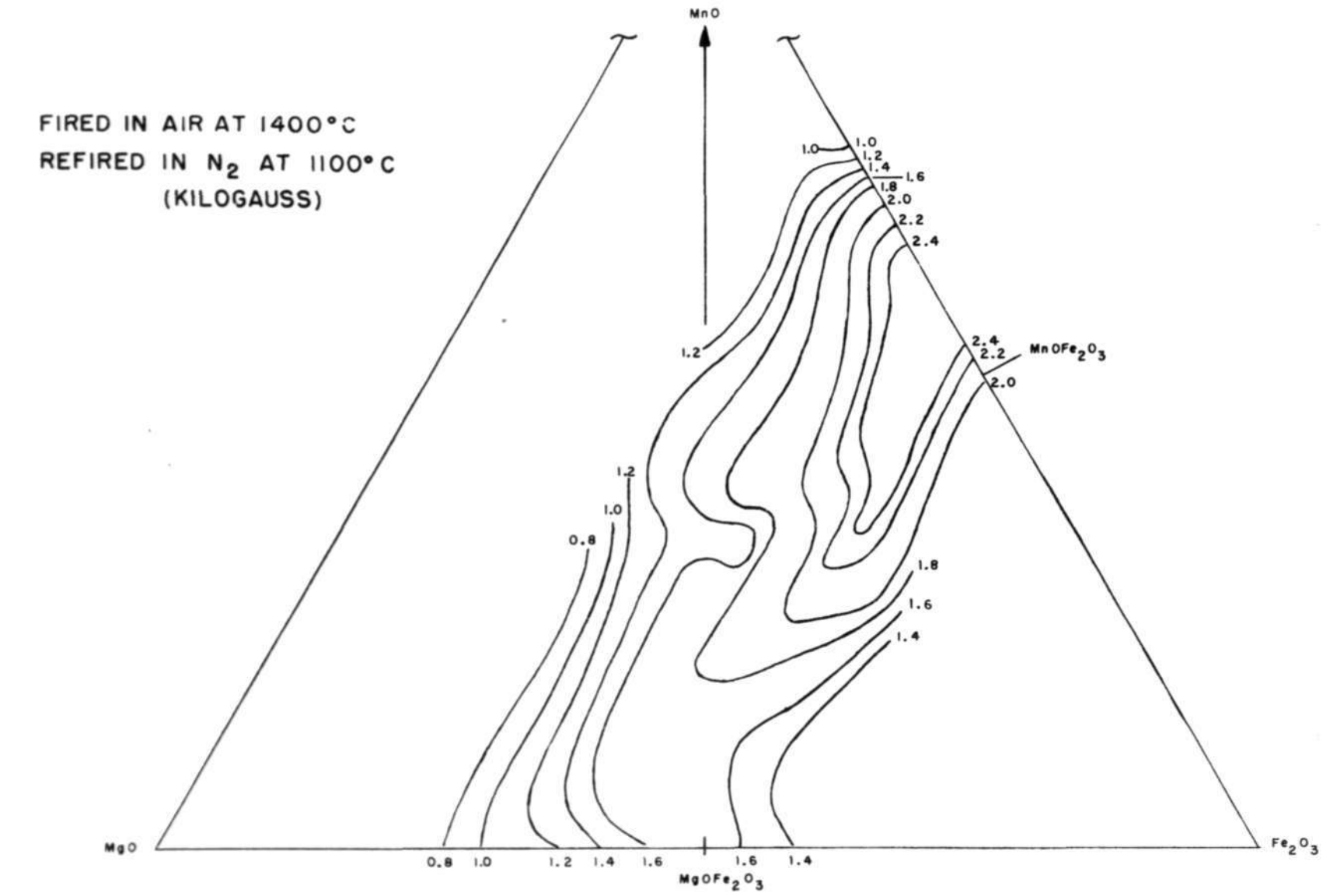
A-57624



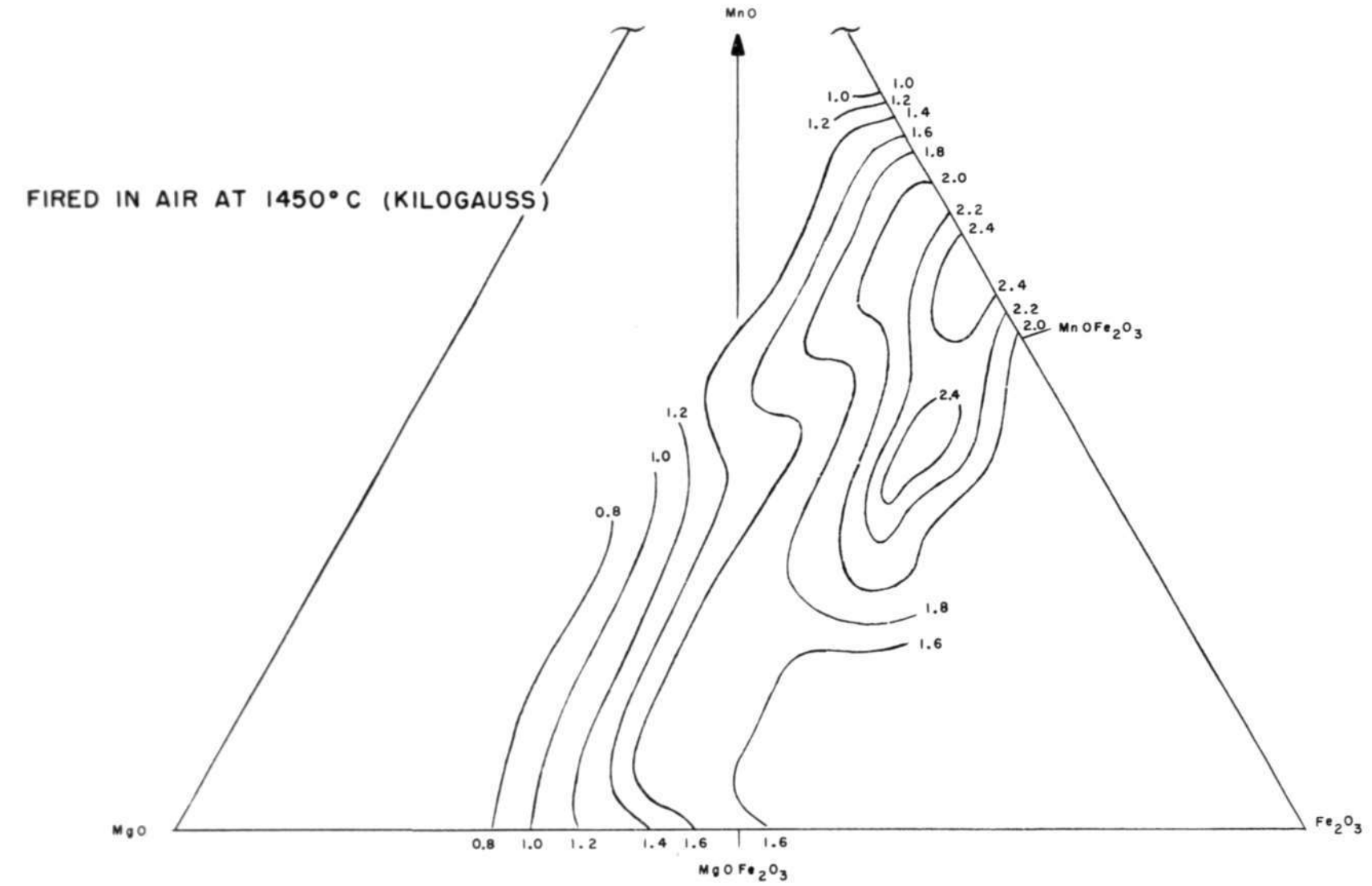
A-5761I



A-57604



A-57610



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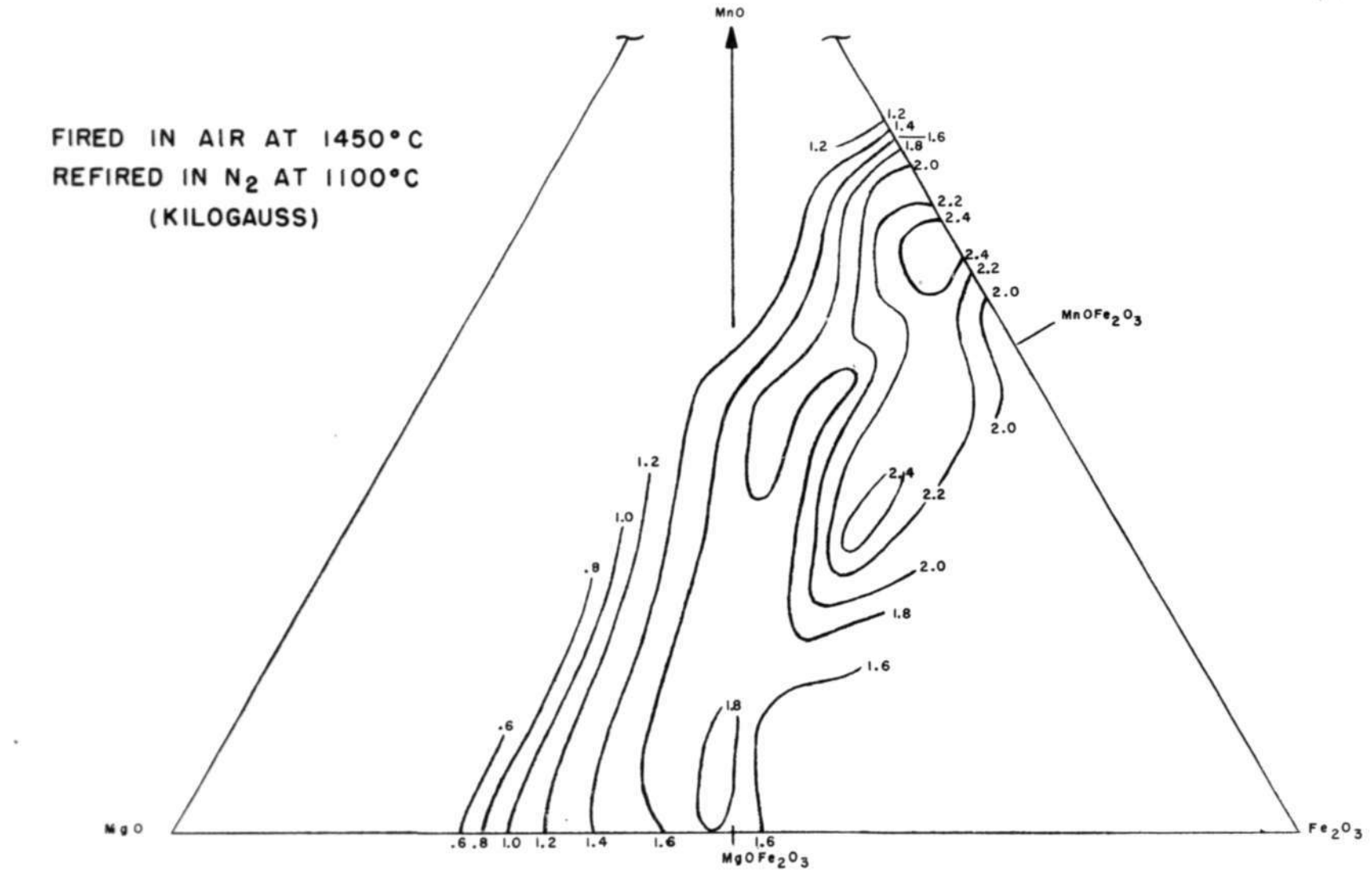


Acknowledgment

This is a summary of work which has been accomplished by many people in the laboratory. J. Sacco, under the direction of F. Vinal, has been responsible for the preparation and processing of the cores. J. McCusker has directed the electrical testing. P. Fergus was responsible for the tabulation of information. F. Maddocks prepared the microstructures.

Signed John B. Goodenough
John B. Goodenough

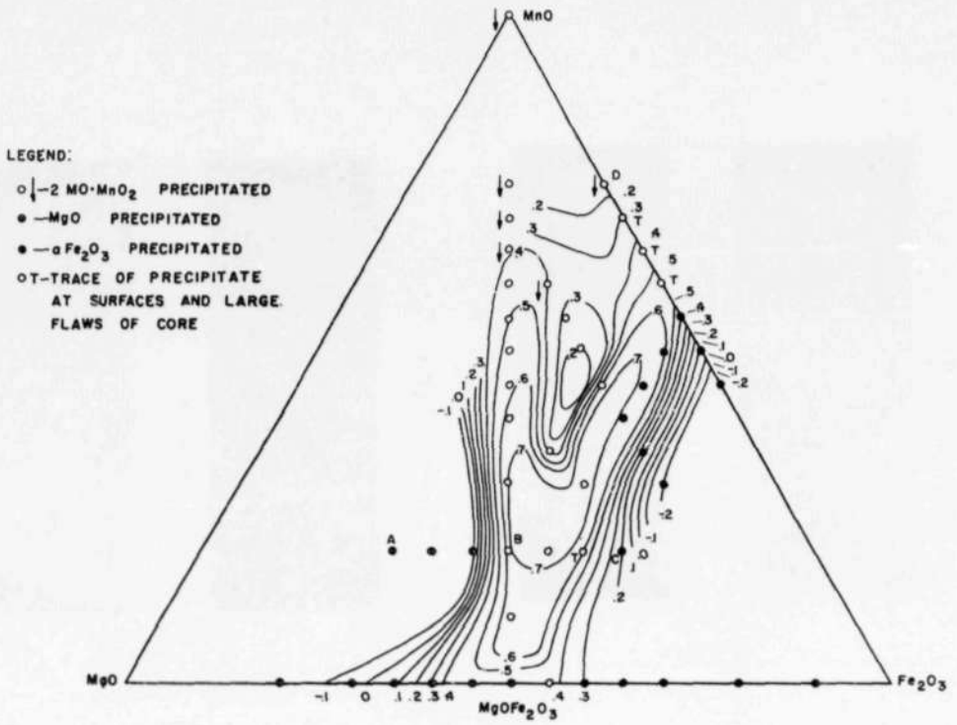
Approved
David R. Brown

JBG/jk

Drawings attached:

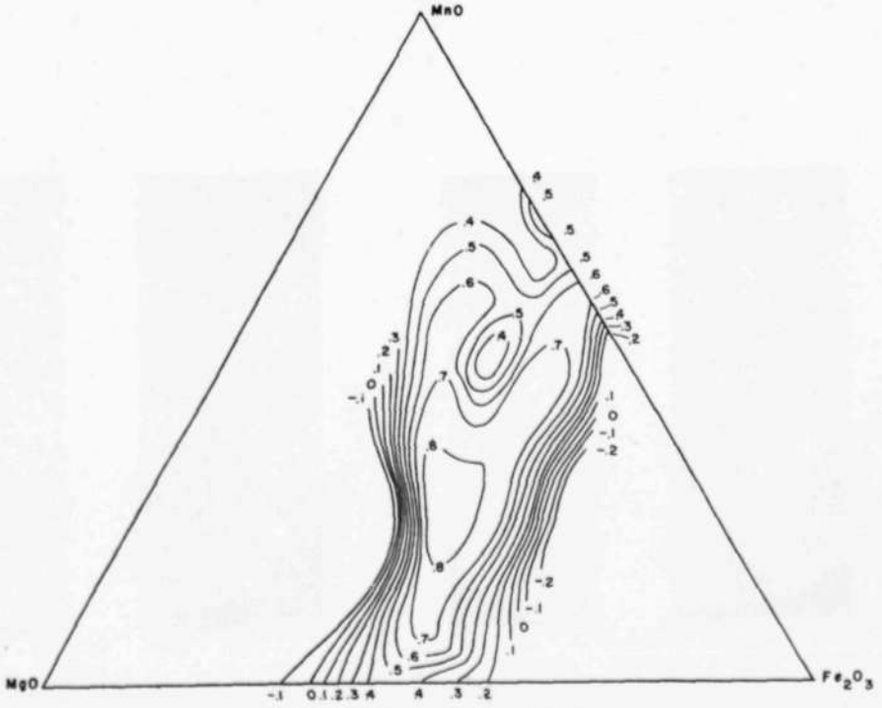
Figure 1 - C-57317
Figure 2 - B-57262

cc: Group 63 Staff
W. N. Papian
B. Lax } - Group 37
S. Foner }



(a)

CORES FIRED IN AIR FOR ONE HOUR AT 1400° C.
CIRCLES MARK COMPOSITIONS FOR WHICH MICROSTRUCTURES WERE MADE.



(b)

CORES FIRED IN AIR FOR ONE HOUR AT 1400° C;
SUBSEQUENTLY FIRED IN N_2 FOR ONE HOUR AT 1100° C.

FIG. 1

CONTOURS OF EQUAL SQUARENESS RATIO R_s

C-57317

B-57262

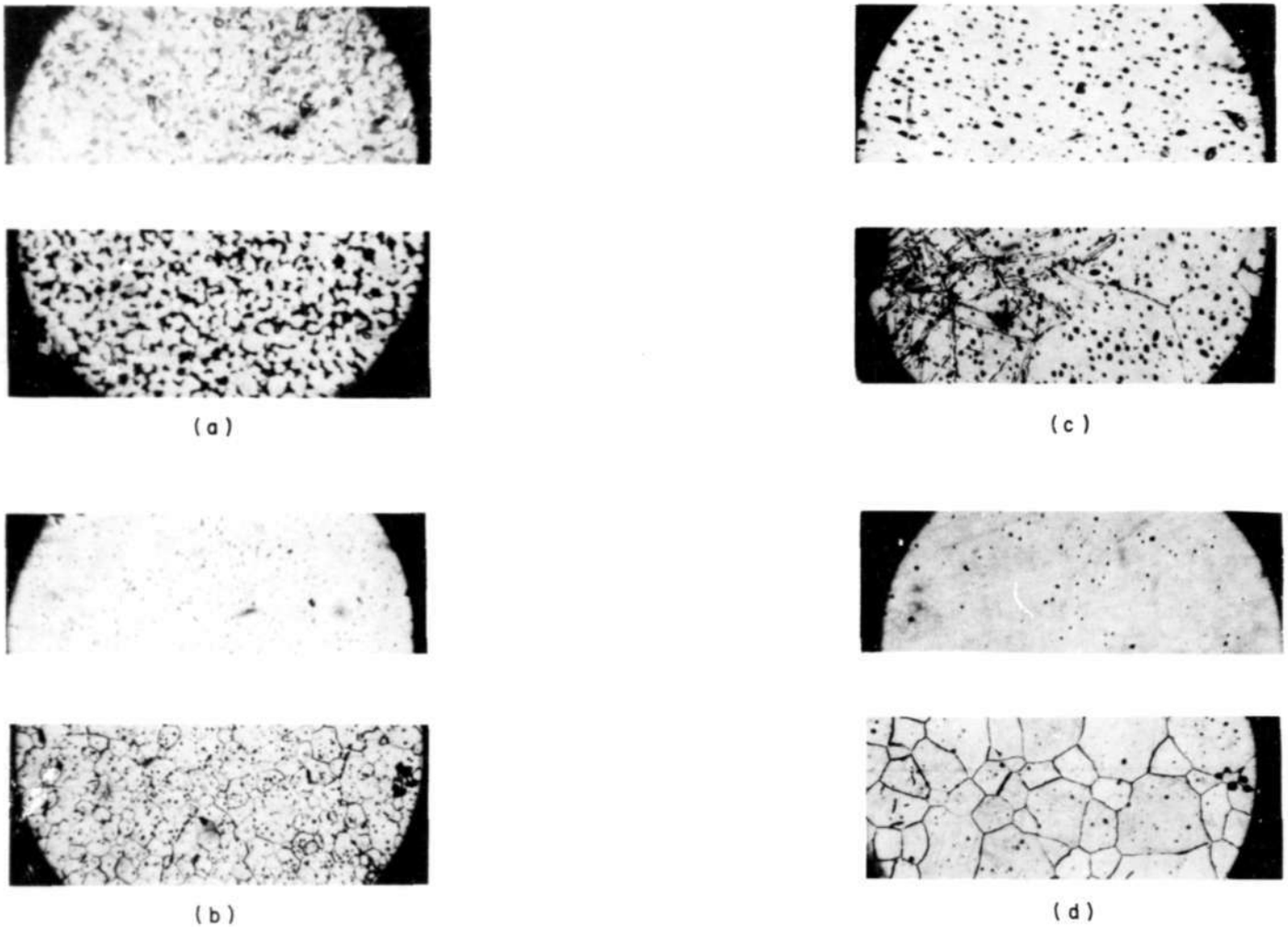


FIG. 2

MICROGRAPHS, BEFORE AND AFTER ETCH, OF CORES MARKED A,B,C, AND D IN FIG. I