Self-lubricating Bearings Fabrication Using Recovered Iron Oxide

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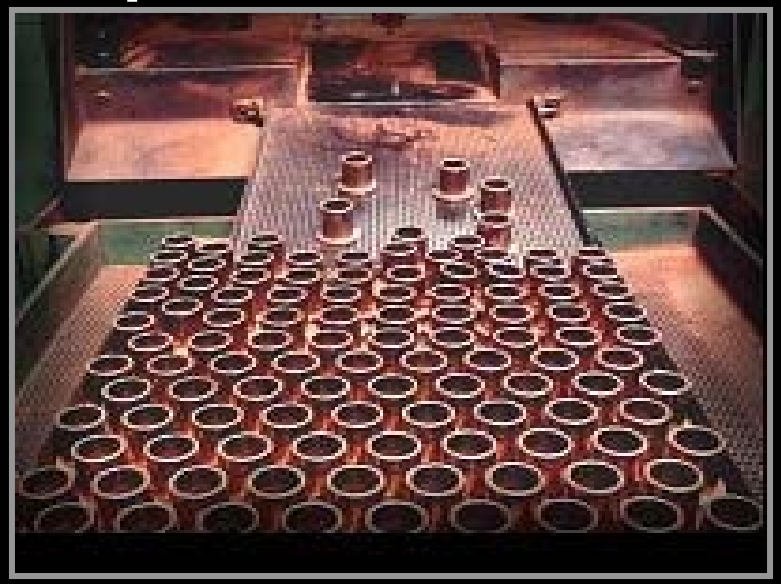
Background of powder metal technology

P/M Process Basics: by the numbers

- **Step One: MIXING**
- **Step Two: COMPACTING**
- **Step Three: SINTERING**



Metal Powder Mixing /Blending/Alloying

- The metal powder is combined to form specific compositions of metal alloys.

Molding

- Powder is compacted to required shape using vertical cold compaction techniques.
- Components are formed under very high pressure ranging from 15 – 70 tons per square inch.

Sintering

- Resulting compact is sintered (heated) according to an appropriate thermal curve using protective atmosphere to reduce oxidation.

Self Lubricating Bearings

- The resulting metal part has a controlled amount of porosity (air pockets).
- The air pockets are then filled via vacuum immersion with oil to produce bearings which are self lubricating.

Typical parts manufactured by PM techniques

Advantage of PM processing:

- Stronger
- More durable
- More versatile
- Minimal waste
- Fewer manufacturing steps

More economic

Alternative sources of Fe have focused on locally derived AMD process sludges

$$FeS_2 + 3.25O_2 + 7.5H_2O \rightarrow + 2CaCO_3 \rightarrow$$

$$FeOOH + 2CaSO_4 \cdot 2H_2O + 2HCO_3^-$$

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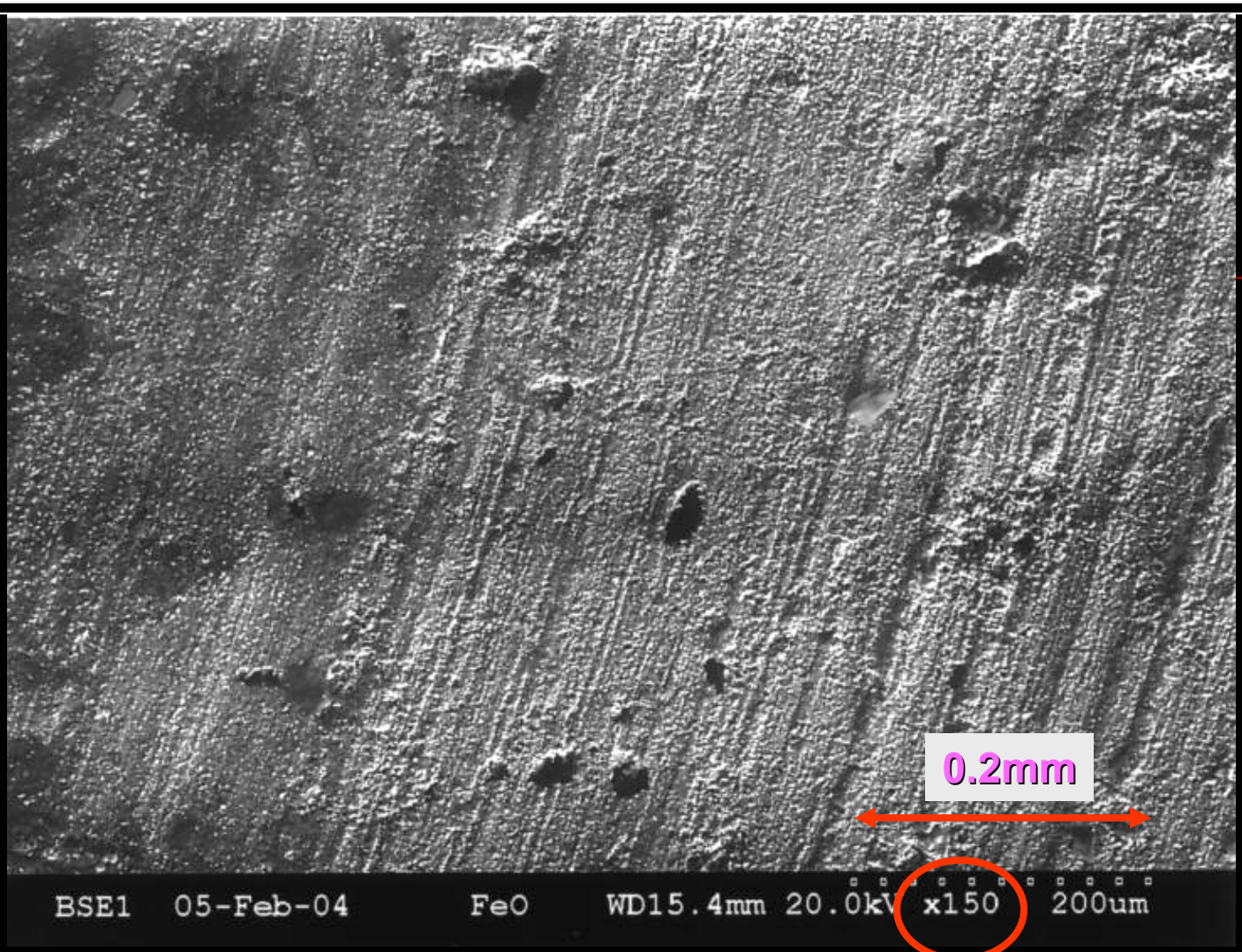
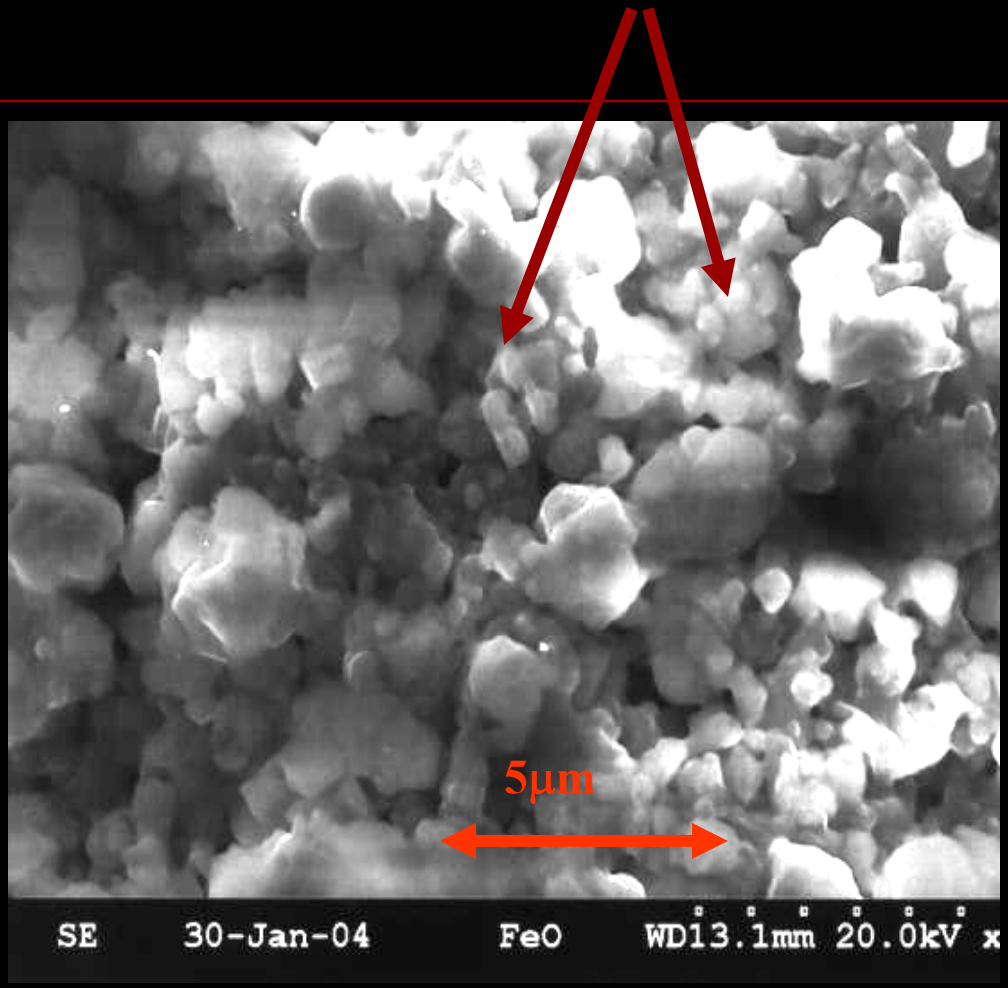
Iron/Calcium Powder

- **Accomplished using thermal reduction and subsequent grinding/milling/sieving mechanical process.**
- **Three separate compositions were used:**
  - 1.) 100% Sludge
  - 2.) 80/20 Bronze Sludge
  - 3.) 80/20 Steel Sludge

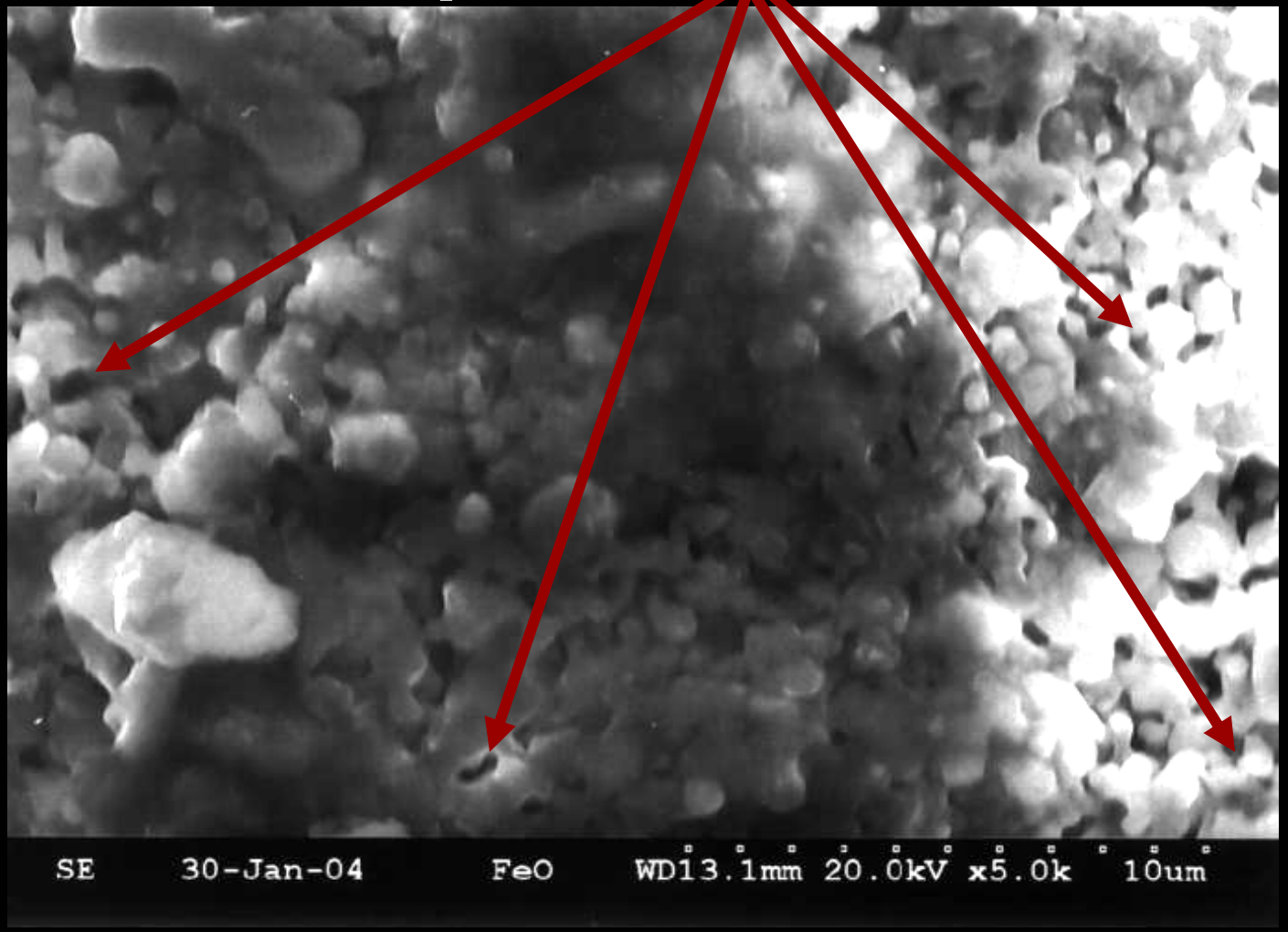


Low magnification image of pressed surface

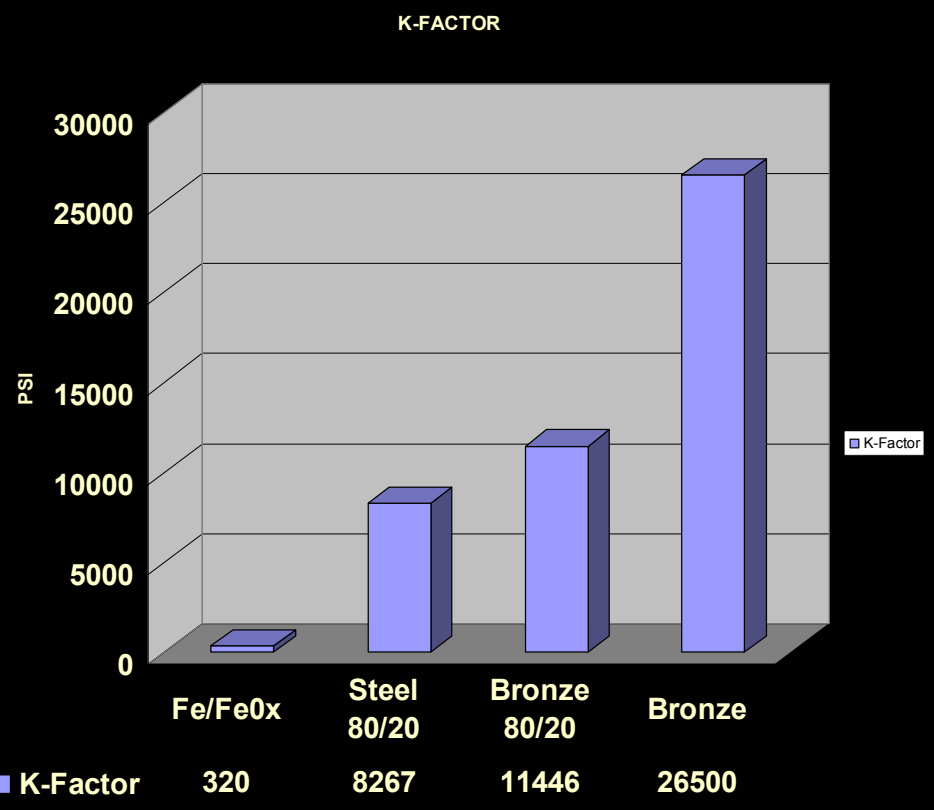
Nanometer-sized starting materials



porous



Strength Constant – K Factor of various common P/M material grades compared to Fe/Ca.



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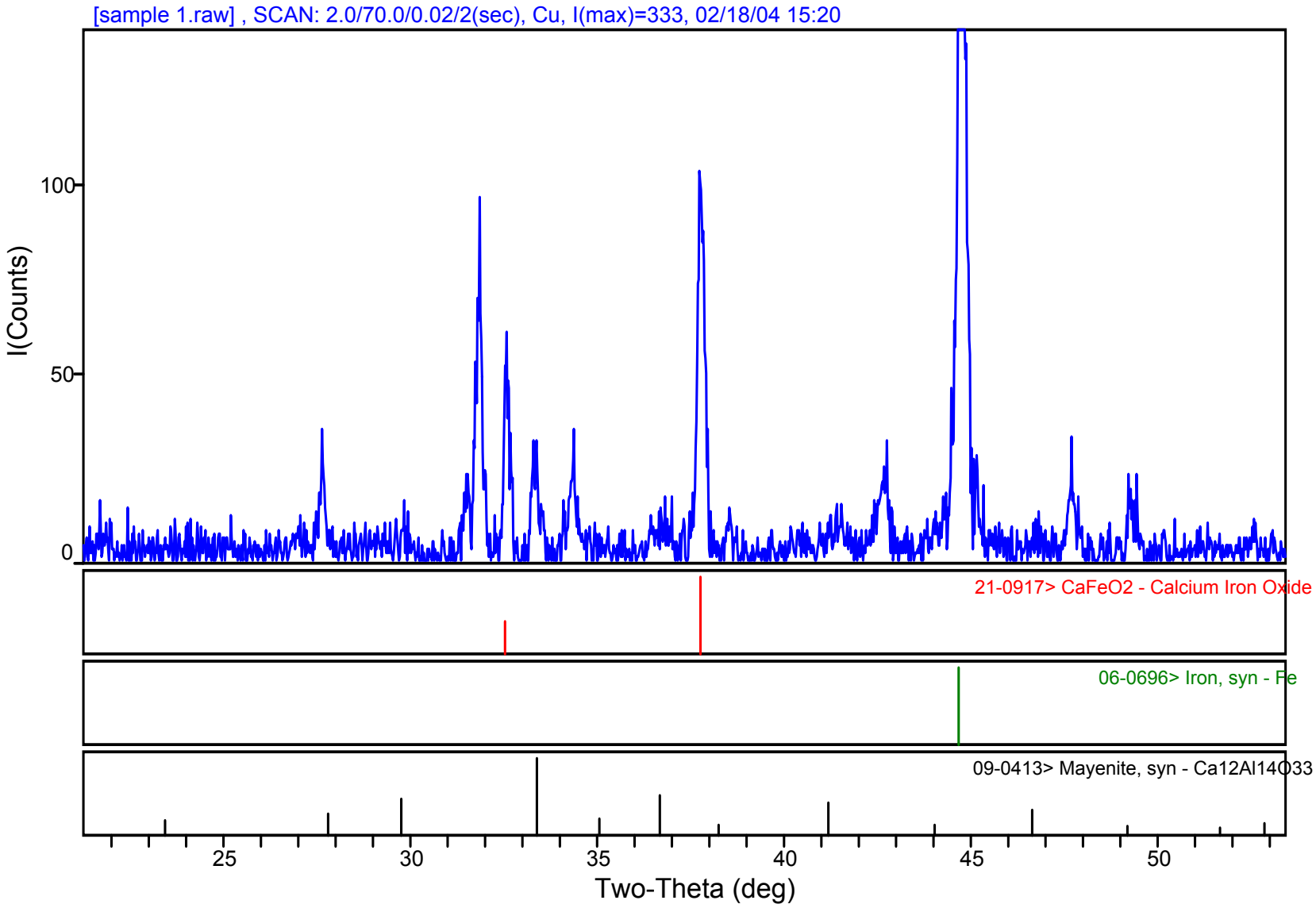
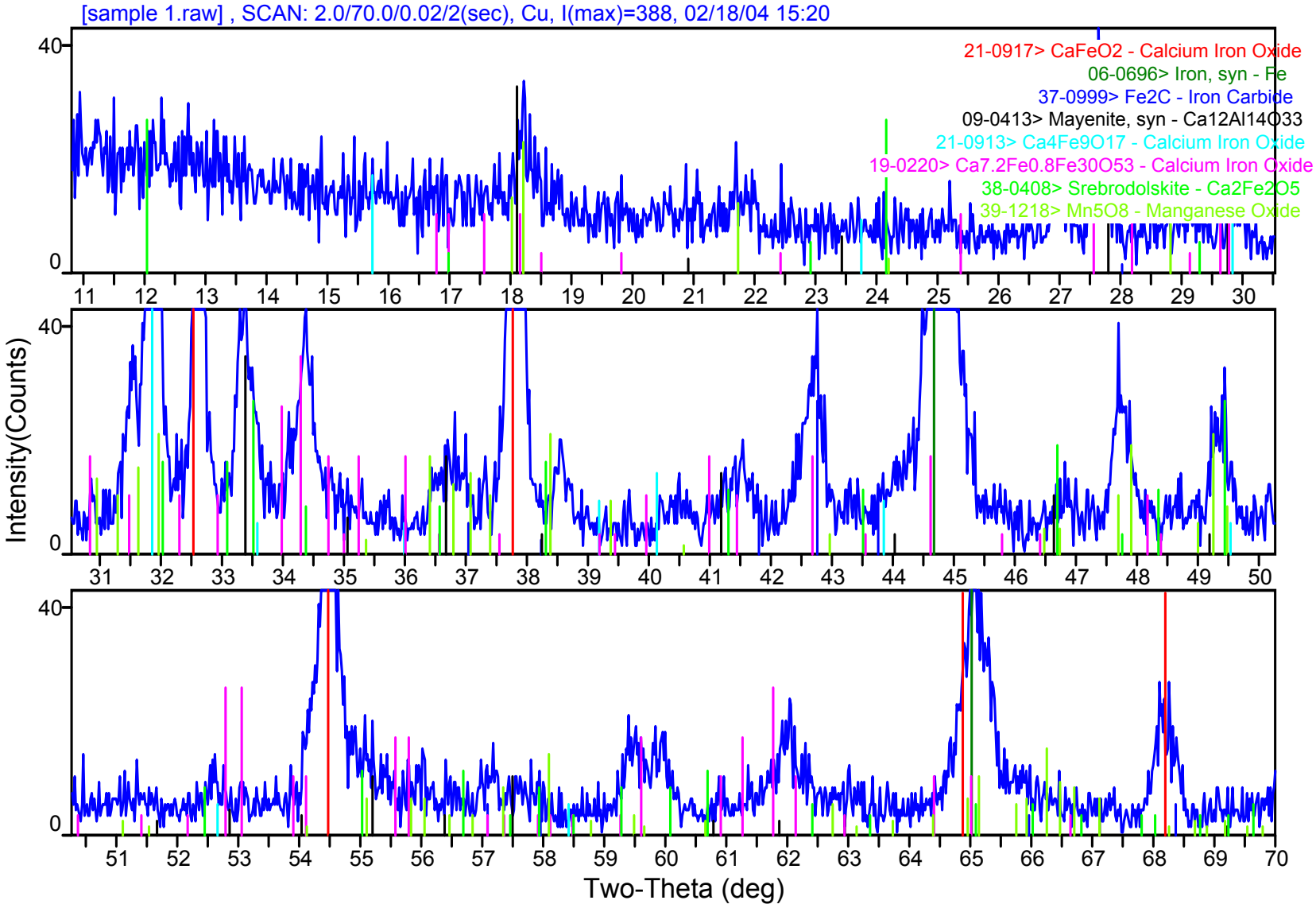
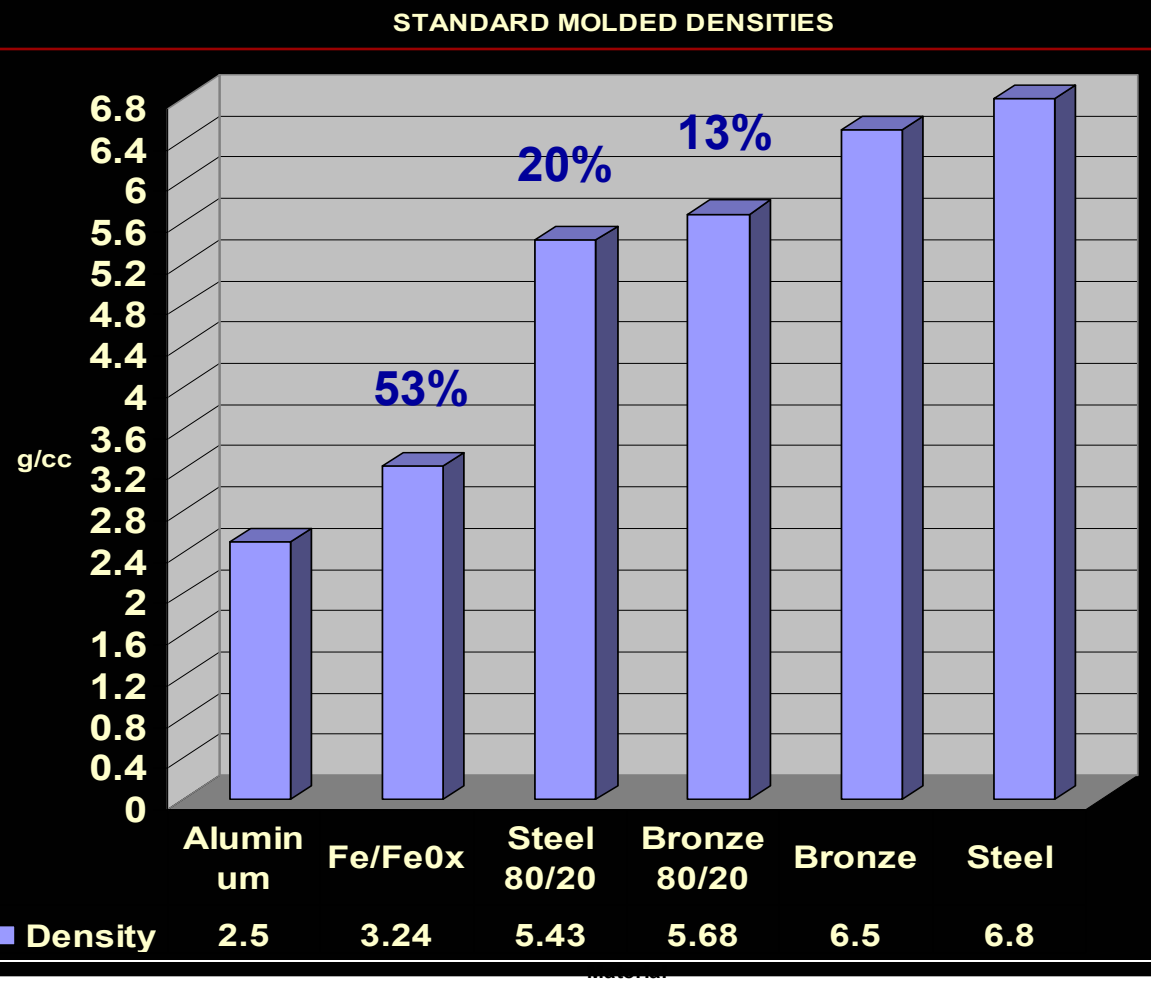

[sample 1.raw] , SCAN: 2.0/70.0/0.02/2(sec), Cu, I(max)=333, 02/18/04 15:20
I(Counts)
100
50
0
21-0917> CaFeO2 - Calcium Iron Oxide
06-0696> Iron, syn - Fe
09-0413> Mayenite, syn - Ca12Al14O33
25
30
35
40
45
50
Two-Theta (deg)

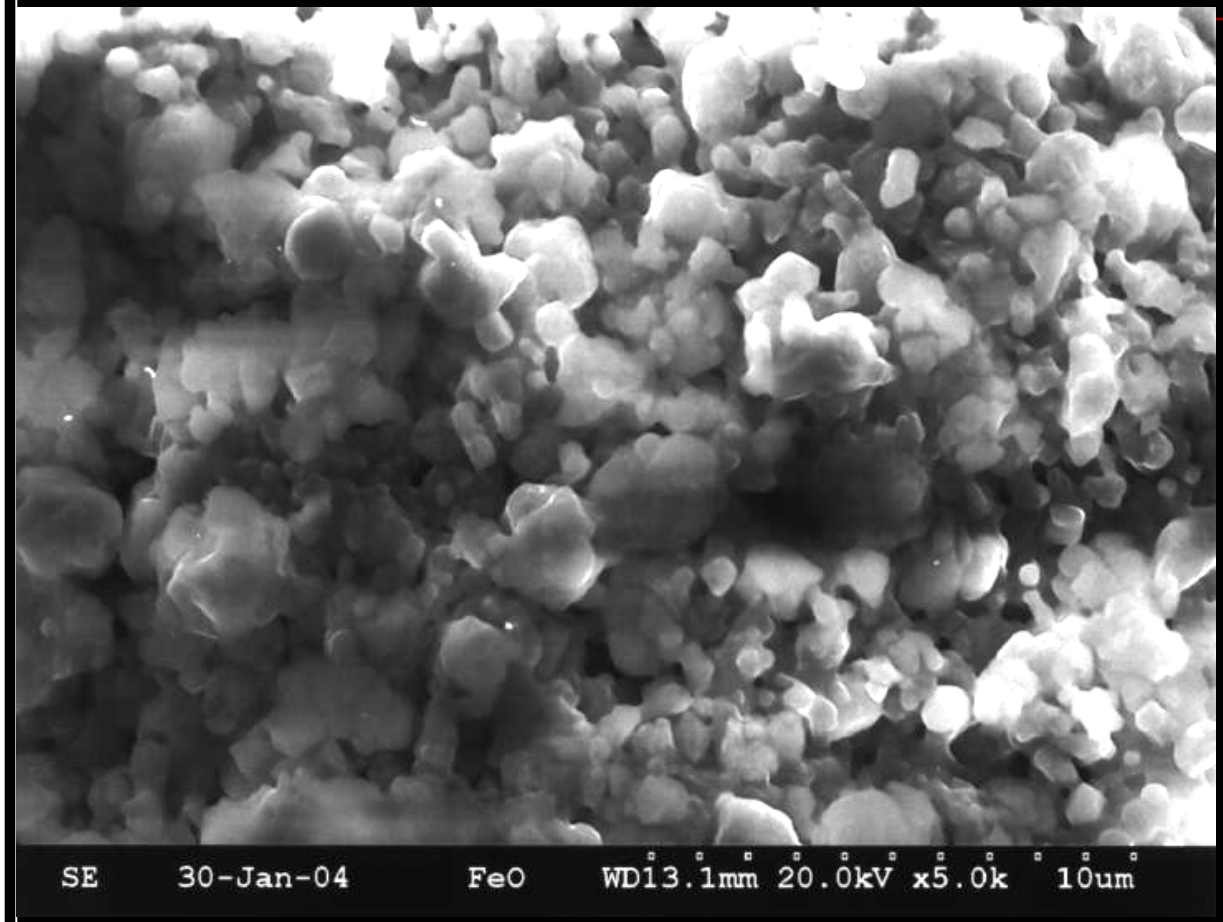

[sample 1.raw] , SCAN: 2.0/70.0/0.02/2(sec), Cu, I(max)=388, 02/18/04 15:20
21-0917> CaFeO2 - Calcium Iron Oxide
06-0696> Iron, syn - Fe
37-0999> Fe2C - Iron Carbide
09-0413> Mayenite, syn - Ca12Al14O33
21-0913> Ca4Fe9O17 - Calcium Iron Oxide
19-0220> Ca7.2Fe0.8Fe30O53 - Calcium Iron Oxide
38-0408> Srebrodolskite - Ca2Fe2O5
39-1218> Mn5O8 - Manganese Oxide
Intensity(Counts)
Two-Theta (deg)

Crystalline Phases Tentatively Identified

	σ
Fe	7.1
Fe_2C	7.2
$Ca_4Fe_9O_{17}$	4.4
$Ca_2Fe_2O_5$	3.9
Mn_5O_8	4.9
$CaFeO_2$	2.0
$Ca_{12}Al_{14}O_{33}$	2.7

Standard molded (pressed) densities of various common P/M material grades compared to Fe/Ca.



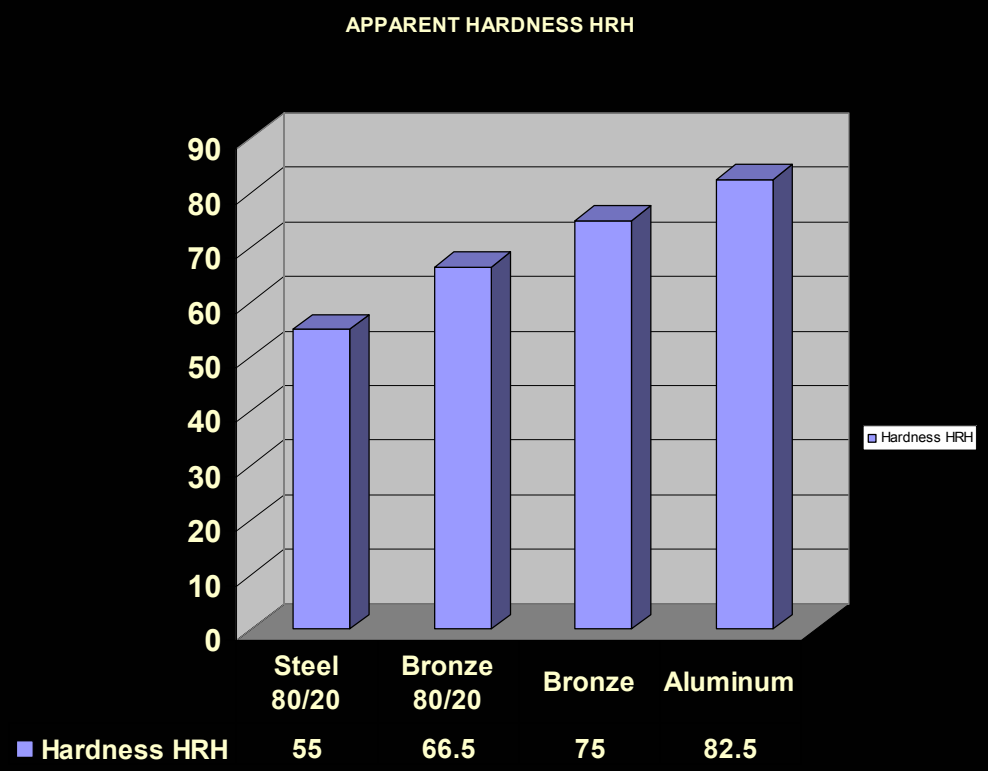


Metal Matrix Composite

Metal Matrix Composites Classification

- **Fiber reinforced**
- **Dispersion strengthened**
  - Up to ~2 vol/o particles
  - Typically a few to hundreds of nanometer-size particles
- **Particle strengthened**
  - Up to 10 vol/o particles
  - Typically micron-size particles

Apparent hardness of various common P/M material grades compared to Fe/Ca.



Conclusions:

- These are preliminary studies that have not been optimized
- Initial testing of fabricated components are very promising