



Herguth Laboratories, Inc.

101 CORPORATE PLACE · P.O. BOX B · VALLEJO, CA 94590

LABORATORY ANALYSIS REPORT

Report Date/Time: 5/8/2004 12:05:04 PM

Prepared for:	Prepared by: Herguth Laboratories, Inc. William R. Herguth 101 Corporate Place Vallejo, CA 94590 800-645-5227 Ext. 3006
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Herguth Project Number/ Sample Description:

Laboratory Number – 601178 - ID: 26-203 BEARING FAILURE ANALYSIS

Laboratory Number – 601179 - ID: 203-7000 HOURS, BEARING FAILURE ANALYSIS

Laboratory Number – 601180 - ID: 204-7000 HOURS, BEARING FAILURE ANALYSIS

Dear :

Please accept this report as our findings on the above project. If you have any questions or comments, please feel free to call.

Conclusion: The bearing damage is the result of contaminated lubricant. There are two contaminant types that have caused these problems to occurs.

1. “Dirt” - Environmental debris consisting of silicon and aluminum.
2. “Oil Balls” - Believed to be formed from mixing oil and coolant, Ref. ¹⁻².

Recommendations: Increase cleanliness levels of the lubricant minimizes damage caused by external contamination. Close attention to small increases in coolant additive levels in the used oil analysis sample results may help detect small coolant leaks. If coolant is not detected, or is not corrected it may lead to hard oil ball formation and the subsequent damage.



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Background and Analysis:

At your request three bearing halves were analyzed to determine the cause of visible damage to the bearings. The visible damage consisted of overlay removal and numerous spots on the surface overlay.

The bearings were analyzed using Optical Microscopy, Scanning Electron Microscopy / Energy Dispersive Spectroscopy (SEM/EDS). The objective of the analysis was to identify the failure mechanism that had occurred on the bearings. The SEM/EDS results are presented in the attached tables and micrographs.

SEM image presentation; a lower magnification image is presented on the left, and a higher magnification image is presented on the right (that area within the square on the lower magnification image).

The EDS identifies only elements, the compounds of which they are a part are unknown. However, in this case we can deduce that if silicon and oxygen are detected silica or sand, (SiO_2), may be present. If silicon, aluminum and oxygen are present we may deduce that clay, ($\text{Al}_2\text{O}_3 \cdot \text{SiO}_2 \cdot 2\text{H}_2\text{O}$) is present.

Similarly, detection of metals such as iron, chromium and copper may not be metallic, but could be oxides or corrosion products. For example iron could be in the compound rust ($\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$).

Carbon is a ubiquitous element in metals run in hydrocarbon oils.

Once again, if you have any questions or comments, please feel free to call.

Respectfully Submitted,

William R. Herguth, CLS

Enclosures – Micrographs and SEM/EDS Analysis

cc: Herguth file - H:\Files\DOC\601178.doc

Reference:

1. SAE Technical Paper # 1999-01-3576 – J.A. Mc Geehan and P.R. Ryason Chevron Products Company, Richmond, CA - “ Million Mile Bearings: Lessons From Diesel Engine Bearing Failure Analysis
2. SAE Technical Paper # 810501 1981, Influence of Oil Balls on Premature Overlay Removal of Diesel Engine Connoting Rod Bearings, Magan J. Patel, Cummins Engine Company.



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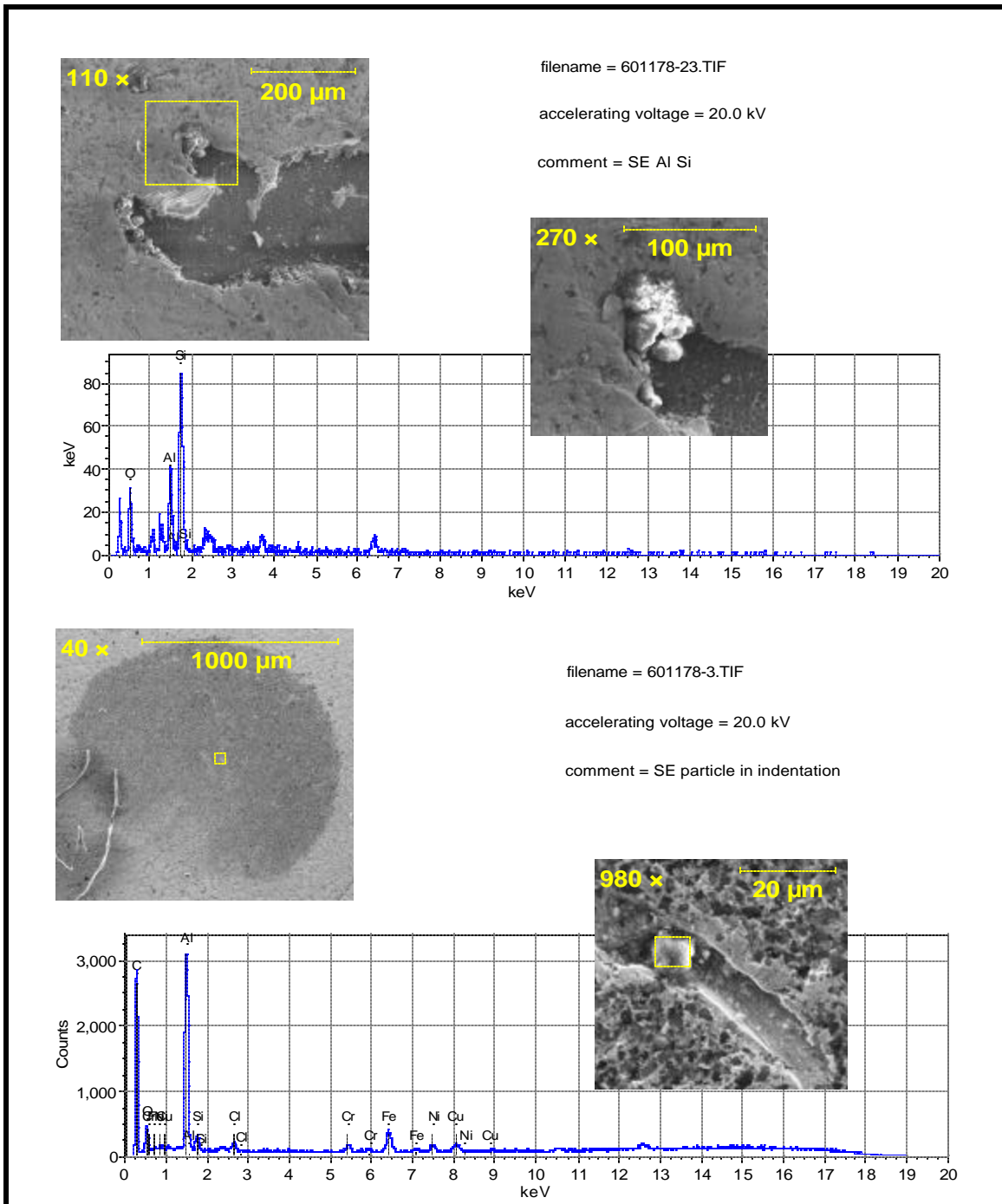
Optical Micrograph of Bearing Surface as Received

Discussion: The micrograph shows the bearing surface has sustained damage. The raised areas are thought to be caused by the “Oil Balls” embedded in the bearing and deforming elevating the softer overlay. The numerous scratches and gouges are thought to be from abrasive materials (dirt) and possibly handling prior to our receiving the bearing. The following SEM images along with the EDS analysis of the elements support these conclusions.



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TOP images show area of missing overlay and silicon and aluminum debris. Probable source is the environment. We speculate that embedment of foreign particles destroys the physical integrity of the overlay, allowing it to be removed or eroded by friction and fluid forces in the oil film. It is removed only in the thin oil film section.

BOTTOM images show raised portion of overlay with honey comb surface which include embedded “oil balls” and large gouge due to aluminum particle.

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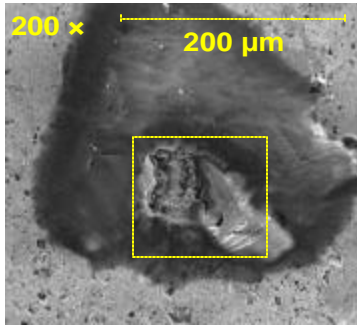
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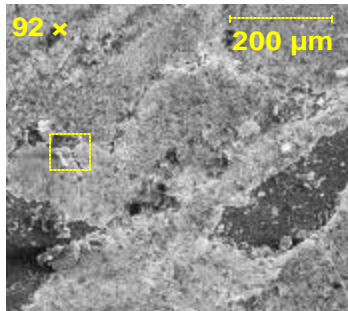
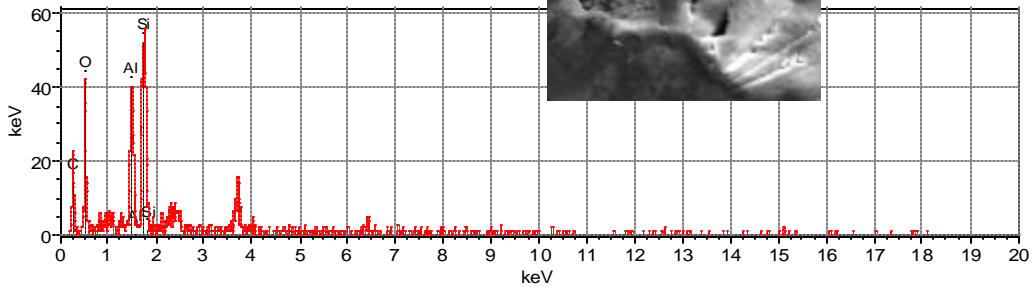
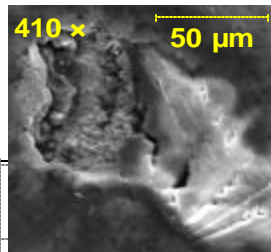
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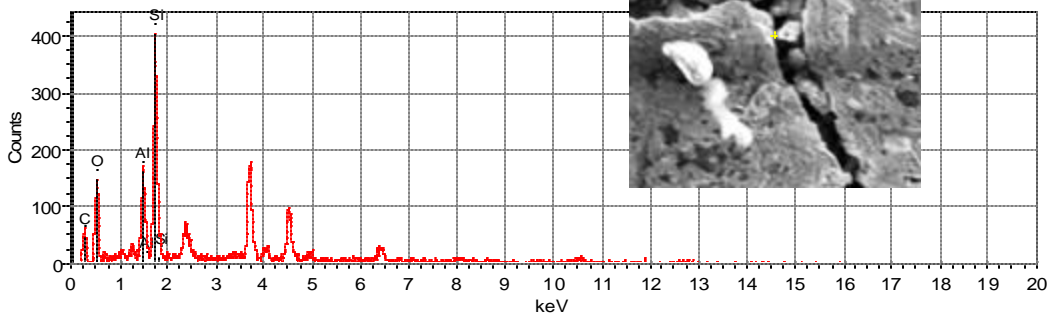
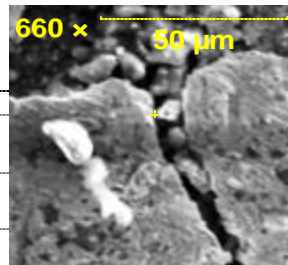
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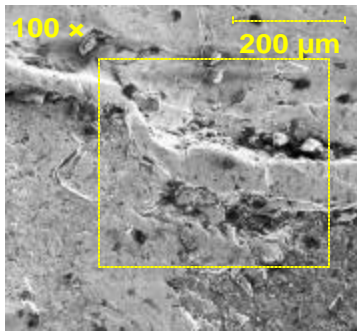


TOP images show embedded particle of silicon and aluminum in overlay. Probable source is the environment. BOTTOM images show distressed and missing overlay with numerous silicon and aluminum particles surrounding the damage.
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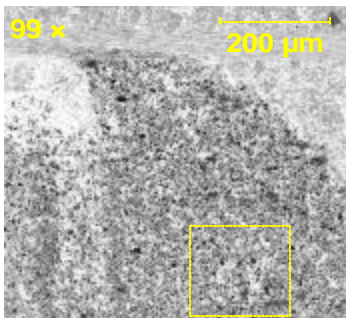
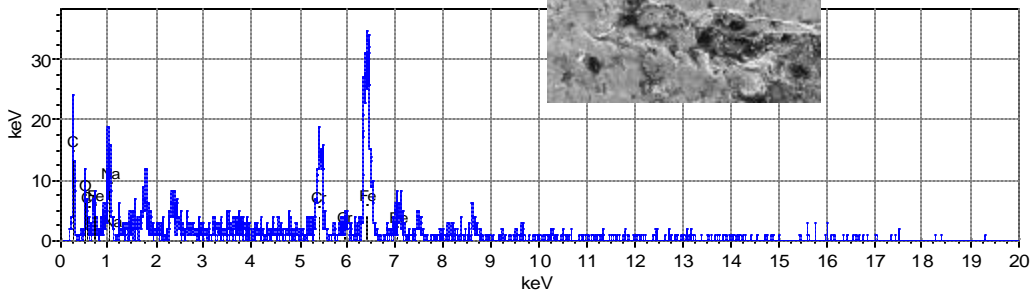
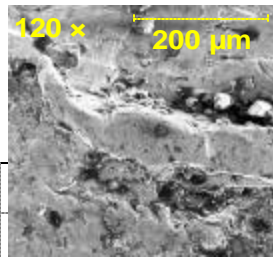
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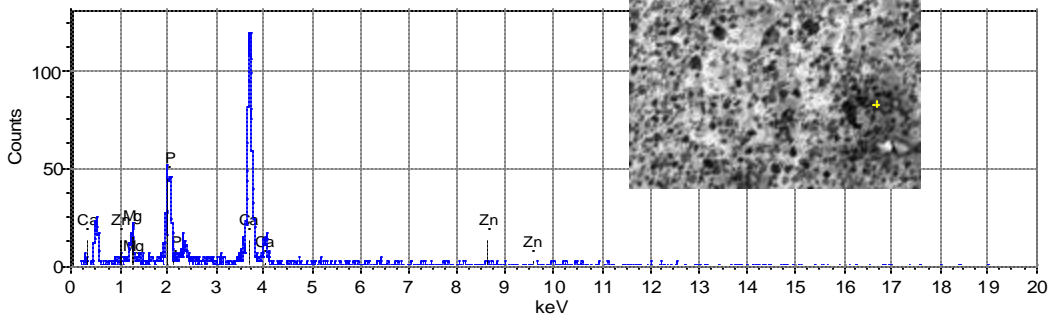
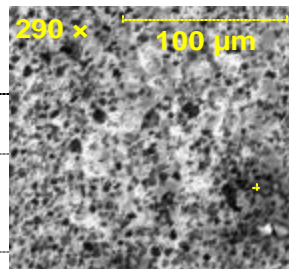
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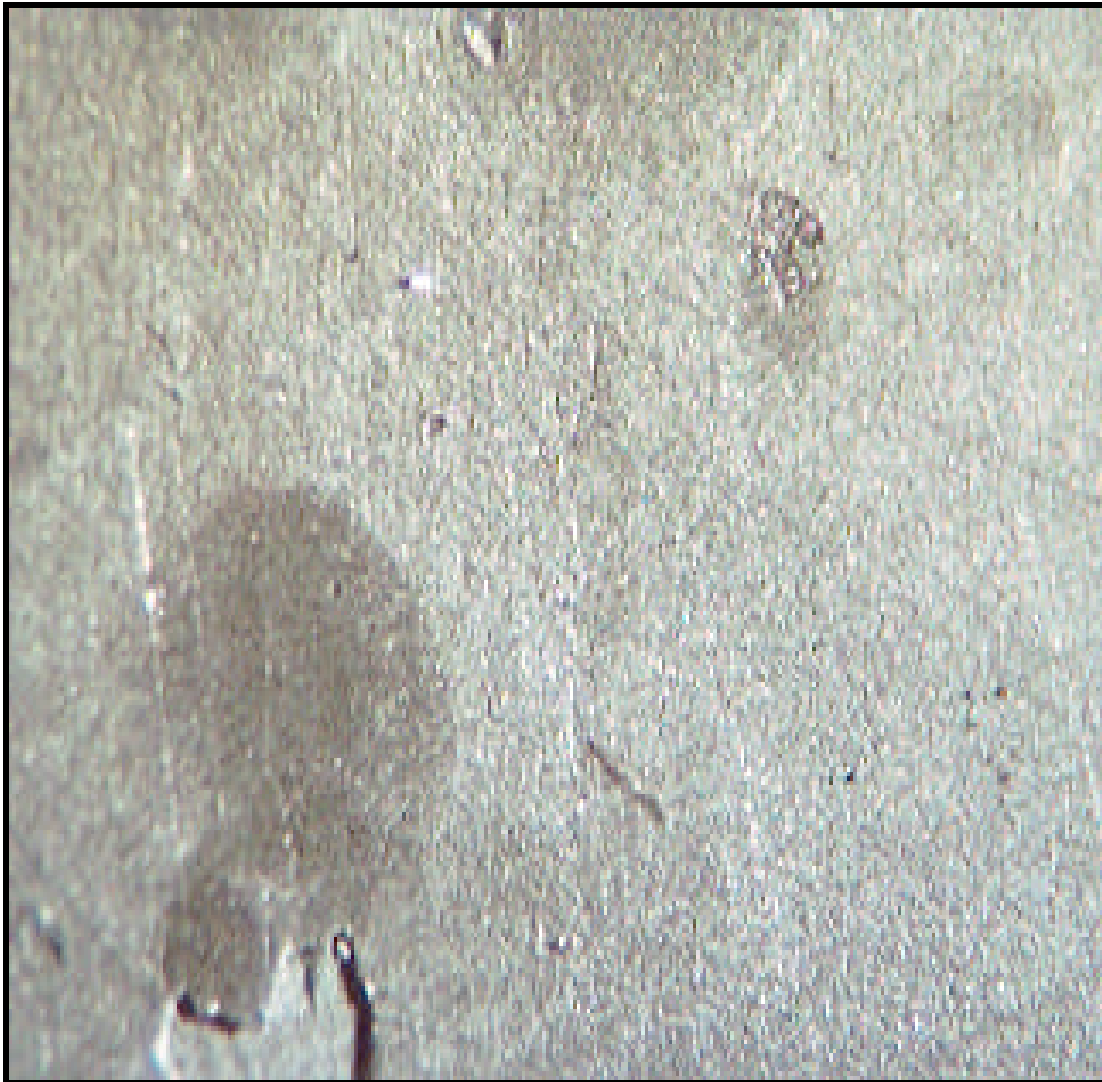
TOP images show distressed overlay with iron and chromium wear debris around the damaged area. BOTTOM images show raised portion of overlay with honey comb surface which includes embedded “oil balls” rich in calcium and phosphorus.
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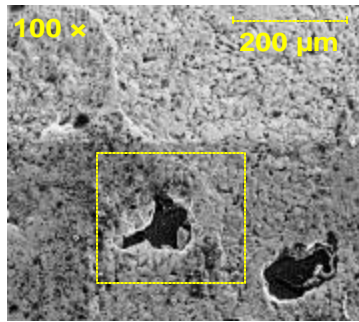
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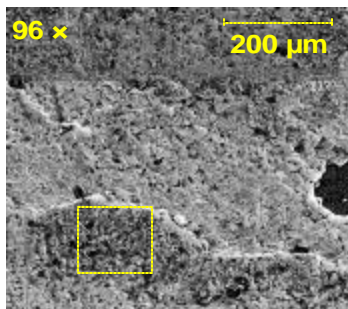
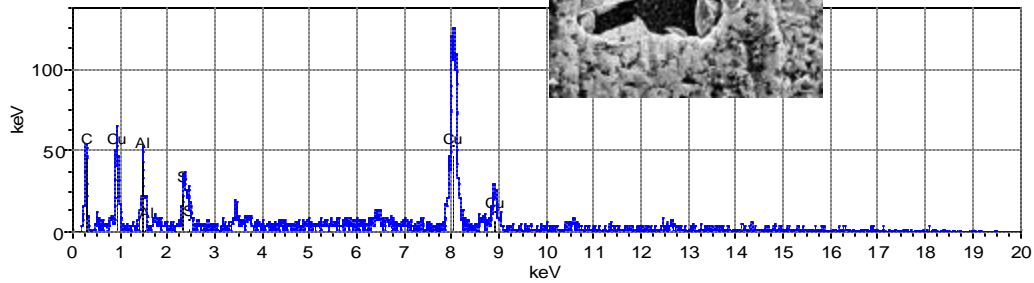
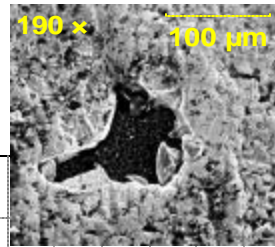
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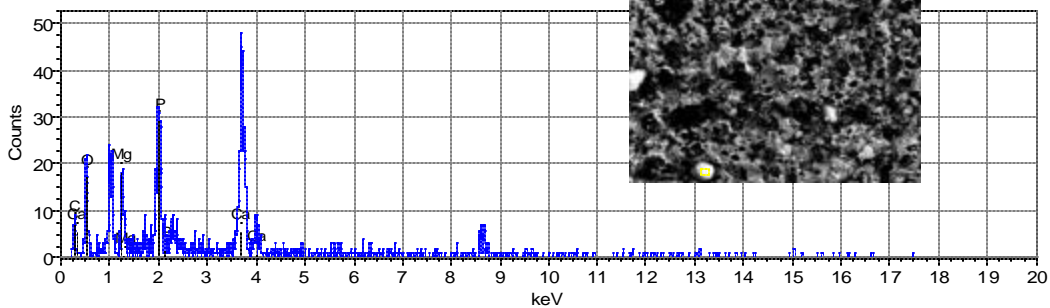
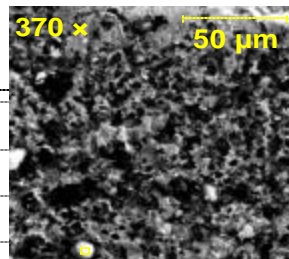
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TOP images show area of missing overlay and a large copper wear debris particle in the void.

BOTTOM images show raised portion of overlay with honey comb surface which includes embedded “oil balls” rich in calcium and phosphorus.

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