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MICROSTRUCTURE OF GOLD FOIL AND MAT GOLD

Photographs of etched specimens of condensed gold foil and mat gold reveal that their density is greatly influenced by the direction and magnitude of the compaction force and the size and shape of the face of of the condenser

An attempt to determine the internal structures of gold foil and mat gold after they have been compacted in cavities has produced a series of photomicrographs which show that fillings of both materials are made up of dense layers and void spaces arranged according to the direction of force during compaction.

The hardness of compacted gold foil and mat gold had been studied previously, and the same specimens were used for this study. Forty of them were prepared by five dentists who were experienced in the use of gold foil. Rectangular cavities measuring approximately 2 mm. wide by 3.5 mm. long and 1.5 mm. deep were prepared in Lucite and filled with the gold materials, which were compacted by pneumatic condensation or hand malleting. After polishing, specimens were subjected to the Vickers diamond pyramid hardness test (1).

The same specimens were etched with *aqua regia* for the present study, and some were ground perpendicular to the surface to get cross-sections. Significant details of the structures of the two materials are shown in the photographs.

Although the compacted specimens are similar in appearance, the materials in them differ. Gold foil is thin in one dimension but large in the other two when compared with mat gold. Uncondensed mat gold is a mass of small crystallites that have dendritic structure and rotational symmetry around the axis. Both materials have the properties of pure gold, from which they are derived.

Cohesion is obtained in the gold materials by removing adsorbed substances by heat, followed by pressure welding. Metallic bonding occurs between gold particles under the forces of compaction. Resistance to deformation increases as the gold is work-hardened, however, and porosity re-

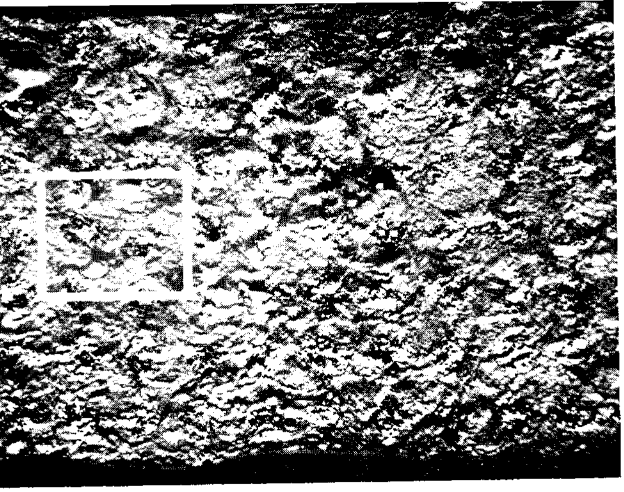

Fig. 1.—Etched surface of a gold-foil specimen of good compaction (×32). Underneath the polished surface the dense gold appears light and the void spaces dark when exposed by etching.

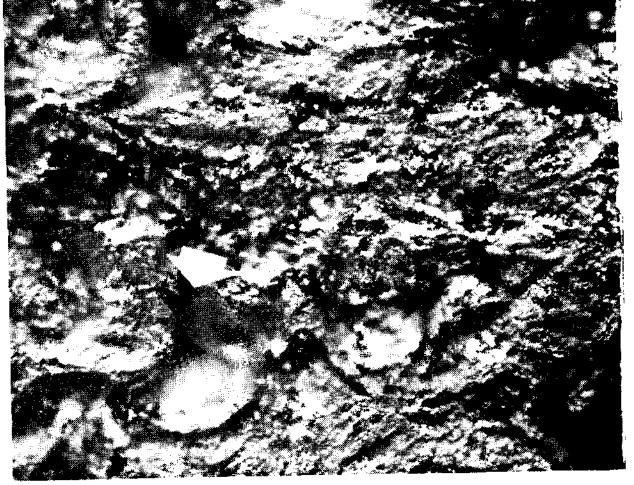

Fig. 2.—When part of the area shown in Fig. 1 is magnified 125 times, imprints from the condenser nib show up. The gold foil is very dense in the bottom of the condenser imprints, and a heavily deformed rolled edge is thrown up at the periphery.

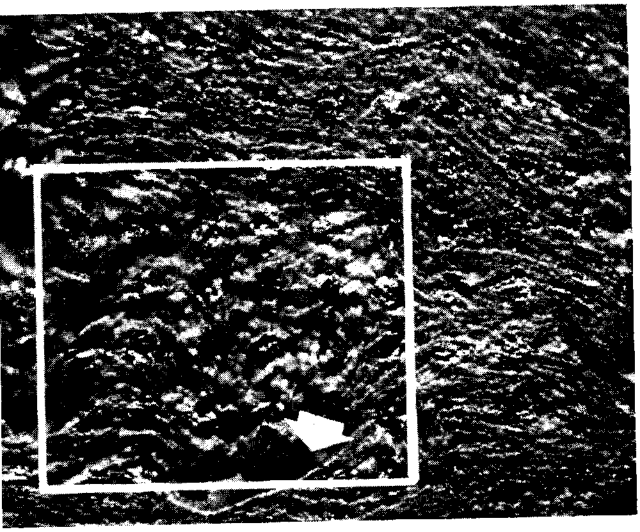

Fig. 5.—A cross-section of an area below and to the left of the Fig. 4 specimen shows a part of a loosely compacted pellet with a height of 0.3 mm. (×125). The dense layers above the foil show good force and careful stepping of the condenser. But the position of the pellet indicates that plastic flow of the gold occurs only for short distances under the face of the condenser. A portion of loosely compacted foil is outlined by the rectangle; the arrow indicates a void.

Fig. 7.—Etched surface of a mat-gold specimen of good compaction (×25). The dendritic structure of the crystalline mat gold is broken down during compaction so that the condensed specimens are composed chiefly of broken crystal fibers. The gold is highly reflective in areas of condenser impact and the void spaces appear dark.

Fig. 8.—A part of the specimen shown in Fig. 7 but enlarged 125 times shows that the greatest density is found in imprints from the condenser point. The rolled edge and general shape of the imprints are similar to the well-condensed foil specimens. In areas of low density the structure is comparable to the dendritic crystals of uncondensed mat gold.

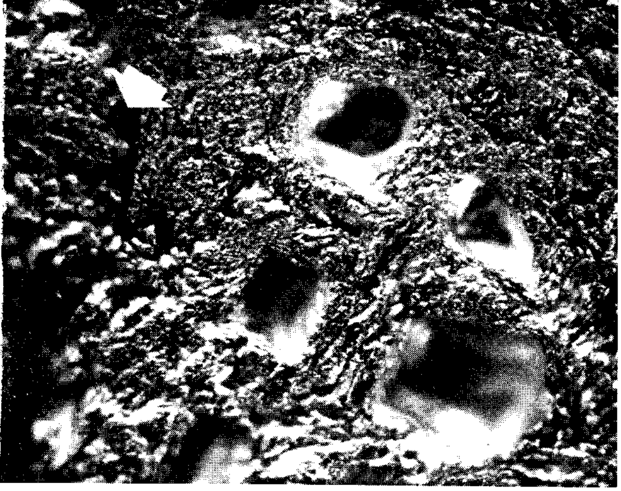

FIG. 3.—Etched surface of a loosely compacted gold-foil specimen (×125) shows five sections of the pattern formed under a single impact of the condenser nib. Dense, smooth gold can be seen at the bottom of the imprints made by the condenser, but the imprints are surrounded by foil that contains voids and laminations. There is a deep crevice (*indicated by arrow*) between a loosely compacted gold-foil pellet near the margin of the cavity and the denser mass toward the center.

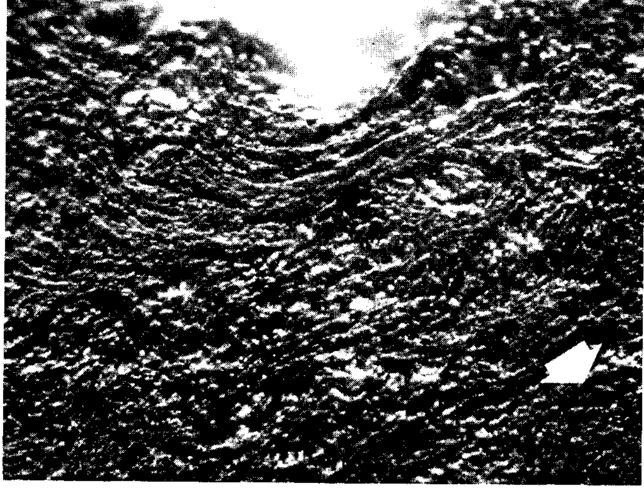

FIG. 4.—An etched cross-section of the foil specimen (×125) photographed in Figs. 1 and 2 shows that dense layers of compacted gold foil alternate with loose or moderately compacted layers. The layers are arranged at right angles to the direction of the condensing force. They parallel the floor of the cavity in the center and change direction toward the line angles. The arrow indicates the direction of compaction toward a line angle; a condenser imprint can be seen in profile at the surface.

FIG. 6.—Melted portions of gold-foil pellets in the etched surface of compacted gold foil (×125) caused by overheating the pellets in the alcohol flame.

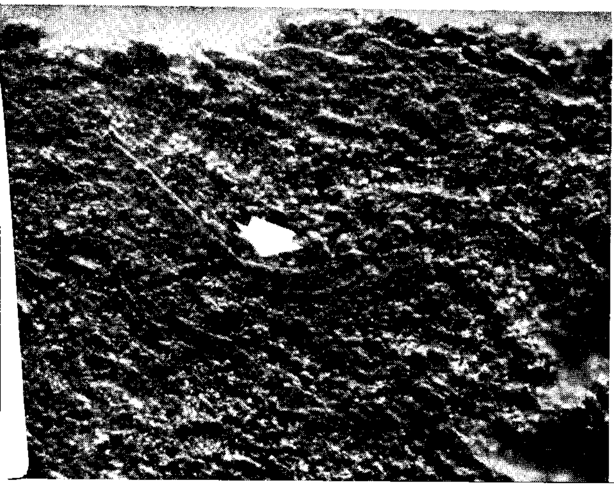

FIG. 9.—A cross-section (×125) of the mat-gold specimen photographed for Figs. 7 and 8 shows a structure similar to that of the gold foil. Layers of dense gold show the direction of condensation (*indicated by arrow*) and the stepping of the condenser. Void spaces at the lower right were created under the same conditions as in the gold-foil specimens.

FIG. 10.—An uncondensed mat-gold specimen (×375) is a mass of small crystallites that have dendritic structure.

sults from incomplete contact between particles. Overheating foil pellets causes them to melt.

Conclusion

The structures observed in the compacted specimens include laminations of dense gold, uncondensed gold, voids, and condenser imprints. The final density is influenced greatly by the direction and magnitude of the compaction force and the size and shape of the face of the condenser. Extensive plastic flow is limited to short distances under the condenser nib; areas not covered by the face of the condenser remain porous. The actual hardness varies widely, depending upon the techniques of the operator.

ACKNOWLEDGMENTS.—Gold foil furnished by Morgan Hastings and Company; mat gold by Williams Gold Refining Company.

References

1. HODSON, J. T., and STIBBS, G. D. Structural Density of Compacted Gold Foil and Mat Gold. Paper read before the Dental Materials Group, I.A.D.R., March, 1960. Abstract in J. D. Res., **39**:765, 1960.