The behavior of homogeneous materials under high-velocity loading is a complicated process that depends on the properties of the constituents, the inner structure of the material, loading conditions, etc. Kul'kov et al. have studied [1] the shock loading of a composite material of the hard-alloy type in which the matrix could be either in a stable or in a metastable state. In the stable austenite state, the material fails without visible change in the structure of samples. If the matrix is in a metastable state, dynamic action with equal collision velocities does not lead to discontinuity of the material. In this case the material structure shows some peculiarities that are not characteristic of the stable state of the matrix: an increase in dislocation and deformation-twin density is accompanied by a martensite rearrangement of the matrix lattice and by the formation of a particular structure of mesocracks [1], which are arranged in an ordered fashion in the sample's volume.

However, these fragmentary data on structural changes have not given a comprehensive idea of the behavior of materials under high-velocity loading. A more detailed analysis of structure evolution is required at various scale levels. The present work is a continuation of [1, 2] and is aimed at studying the evolution of the structure and phase composition of the material at different scale levels: a) the macrolevel, i.e., the sample as a whole or a part of it (1-10 mm); b) the mesolevel, the level of a grain (1-20 μm); c) the microlevel, a slip band, second-phase particles (10^{-7}-10^{-8} m) (in accordance with the classification of [3]), and their interaction.

A hard alloy of tungsten carbide and high-manganese steel (30% by weight) was studied. The matrix was in the metastable austenite state formed by saltpeter hardening above 1370 K. The average size of the starting tungsten carbide grain, as determined by the secant method [4], was 2.5 μm.

Samples were taken in the form of disks 60 mm in diameter and 4.5 mm in thickness. Shock loading was performed by a cylindrical steel element striking a plate of the studied alloy at a velocity of about 1200 m/sec. The macro- and microstructures of the loaded samples were studied with a NEOFOT-21 optical microscope. The changes in the phase composition of the material were recorded by the x-ray diffraction method on a DRON-UM1 setup with filtered copper radiation.

The study of the loaded samples showed significant structure changes at the different scale levels. Let us discuss these sequentially.

Macrolevel. The macropicture of fracture demonstrates that the disks are broken into large fragments due to propagation of radial cracks from the striker-target contact and is similar to that of WC-Co alloy fracture observed in [5]. On some of the fragments in the immediate vicinity of the puncture hole, one can see sickle-shaped cracks. On the rear side of the plate, a split with a diameter twice as large as that of the puncture hole is formed. The central part of the striker-target contact consists of small fragments of different shapes.

Macrostructural investigations of the cross-sections of composite samples after shock loading showed that on the rear side of the target there is a characteristic material zone with a size equal to half the sample...
thickness whose structure differs from the main structure (Fig. 1). This zone can be represented as overlapping cup-shaped regions in which the extent of overlapping decreases with distance from the split cone up to complete separation of the regions. The width of the regions on the rear surface equals the difference between the crater and the puncture hole radii. Inside the cup-shaped zones one can see macrocracks propagating from the rear surface through the entire zone thickness with numerous branchings.

Analysis of the interface between the rear zone and the main material shows that there are a great number of mesocracks, most of which are formed into tracks similar to those of [1]; in a narrow region of the sample the tracks are parallel to one another and perpendicular to the shock-wave propagation direction, and in the material volume that is immediately adjacent to the contact site they are parallel to the crater (Fig. 2). The distances between the cracks in the track obey the rule described in [1].

The microrigidity in this region of the material varies from 7 GPa (which corresponds to the initial state of the sample) to 10 GPa with a typical oscillation period equal to the size of cup-shaped zones. As the distance between these zones and the shock center grows, the absolute value of the oscillations in them decreases with preservation of their period (Fig. 3).

Mesolevel. Microstructural investigations of the interface between the cup-shaped zones and the main material revealed a sudden transition from the composite matrix structure, which consists of separate well-faceted tungsten carbide grains located in the binding phase, to large rounded carbide conglomerates (Figs. 4a and 4b); the binding phase also changes its morphology. Inside these conglomerates, regions of a new white (unpickled) phase exist, which are mostly elongated and lens-shaped. Columnar formations of coalesced