Carbon in the Witwatersrand Goldfields: Its Nature and Origin

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The nature and origin of the so-called 'carbon' in the Witwatersrand goldfields has long been an important and controversial question because an estimated 40% of the gold is intimately associated with the carbon. Concerning this question it is first of all essential to distinguish between bitumen and kerogen, two of the most prevalent forms of reduced carbon on the planet. Kerogen is the remains of former living organisms. Specifically, it is a polymer-like organic substance which has remained in situ since deposition. In contrast, bitumen is a macromolecular organic compound which was once mobile as a viscous fluid but which has since solidified. In common organic solvents, kerogen is insoluble, whereas most bitumens are soluble. Neither bitumen nor kerogen consists solely of carbon though of course both are converted to graphite under high-grade metamorphic conditions.

A wealth of field evidence bearing on the nature and origin of Witwatersrand carbon indicates that apparently the carbon seams are primary sedimentary features, and therefore indigenous to the host siliciclastics. For example, the carbon seams are in numerous instances abruptly truncated by paleoerosion channels. However, veinlets of carbon also occur, and microscopic fractures in quartz clasts are in some instances filled with carbon. Isotopic analysis of Witwatersrand carbon reportedly reveals a range in delta ^{13}C from ~-23.6 to -39.2 ‰ for the insoluble portion of the carbon. Associated soluble organic matter reveals small differences (to ~ ± 2.4%). The genetic link generally agreed upon is confirmed by results of organic petrographic work which shows that both kerogen and bitumen commonly occur together in Witwatersrand carbon seams. The kerogen components include inertinite-like (incipient or broken cell structures like semifusinite) macerals, and vitrinite-like gelified remains of humic tissues. That several different macerals (a term which describes the shape, texture, and optical nature of petrographically identifiable entities in kerogen) are observed, as for example, in Vaal Reef carbon, is precisely a characteristic of oil source rocks in that no one maceral (and certainly not bitumen) occurs to the exclusion of all others. Thus in the Witwatersrand, as in some Phanerozoic source rocks (less commonly perhaps in Precambrian sediments), solid bitumen occurs where evidently either it has been generated, or where it has been arrested during migration through the rock. As such, it is a derivative of kerogen from shales and /or from carbon seams within the Witwatersrand basin.