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Composition of air bubbles in polar ice (Hans Oeschger Medal Lecture)

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The idea to reconstruct the atmospheric composition of the past, by measuring air extracted from bubbles of ice, is 50 years old. However, first results, especially concerning the concentration of the important greenhouse gas CO_2, have been very disappointing. A steady improvement of analytical techniques and the availability of new interesting, appropriate ice samples, finally allow to reconstruct the atmospheric CO_2 concentration of the past few hundred thousands years quite accurately. Records covering the past 650,000 years show that atmospheric CO_2 concentration was never higher than 300 ppm during this period, compared to a modern concentration of over 370 ppm. In the last 420,000 years the range of the CO_2 concentration was between 180 ppm during glacial epochs and 300 ppm during interglacials. Before 450,000 years BP, when mean temperature was lower during interglacials, CO_2 concentration reached only about 260 ppm. This is further evidence for a close relation between global, climatic cycles and atmospheric CO_2 variations. During the last glacial epoch variations in CO_2 concentration on the order of 20 ppm are observed. During the transition from the last glacial epoch to the Holocene the atmospheric CO_2 concentration increased from about 189 ppm to about 265 ppm. At the beginning of the Holocene the concentration first decreased to 260 ppm at 8,200 years BP. The decrease was followed by an almost linear increase from 260 ppm to 280 ppm at the beginning of the last millennium. The general trend of CO_2 concentration during the last millennium shows an almost constant level of the concentration during the first eight centuries of about 280 ppm, followed by the dramatic anthropogenic increase during the last two centuries. However, concentration variations of the order of 2 - 5 ppm are also observed in ice representing the first eight centuries of the past millennium. But these variations with amplitudes of about 2 ppm and durations in the order of a century, which are very important for the understanding of the global carbon cycle, are not consistent

between ice cores from different drilling sites. Are additional improvements of analytical techniques needed, to allow a reliable reconstruction of such variations, or are non systematic processes during enclosure and storage of air in bubbles, leading to changes of the composition, making such accurate reconstructions impossible?