KIMBERLITES AND THE MANTLE SAMPLE - CAN WE DECODE THEIR GEOTECTONIC MESSAGE?

H. Helmstaedt and D.J. Schulze
Dept. of Geological Sciences, Queen's University, Kingston, Canada, K7L 3N6

Although studies of kimberlites and their mantle-derived inclusions still convey contradictory geotectonic messages (the models of diamond genesis by Haggerty (1986) and Schulze (1986) are two recent examples), geotectonic information derived from such studies should ultimately fit into compatible upper mantle models that can be integrated with those from other Earth science disciplines. Tectonic aspects of kimberlites and related rocks involve their local and regional structural settings, their larger-scale geotectonic controls, the physical processes controlling kimberlite formation in the upper mantle, and the ascent through the lithospere. Inclusion studies (involving xenoliths, megacrysts, and diamonds thought to have equilibrated under upper mantle conditions) yield information about the composition, physical conditions of formation, textures, and structures of small isolated samples that are combined to obtain a picture of the composition, physical conditions, structure, and origin of the lithospheric column traversed by the kimberlite. Viewed in this context, geotectonic bits of information from kimberlite and inclusion studies can be divided into those contributing to the understanding of processes of upper mantle formation and those monitoring later modifications of the mantle. As the mantle evolves continuously, such categories naturally are end members of a continuous spectrum of processes. However, the division makes sense for diamondiferous kimberlite provinces on Precambrian shields, where the subcontinental lithosphere, from which most of the mantle sample was derived, was assembled in Early Precambrian times, whereas the kimberlite eruptions and other intraplate magmatism were triggered by distinctly later events.

For the southern African craton, where Archean isotopic signatures have survived in xenoliths as well as in diamond inclusions (e.g. Kramers, 1979; Richardson et al., 1984; Richardson et al., 1985), the origin of the lithospheric section traversed by the kimberlites becomes a problem of Archean tectonics. If integrated with current models based largely on rocks from Archean granite-greenstone and granulite-gneiss terrains, xenolith studies will lead to a much improved understanding of Archean tectonic processes.

Opinion amongst students of Archean rocks has long been divided as to whether the evolution of the Archean lithosphere can be explained in terms of plate tectonic processes (e.g. Kroner, 1981). Two of the major arguments against Archean plate interactions have been the apparent absence from the Archean rock record of ophiolites and eclogites (e.g. McCall, 1981), the presence of which in Phanerozoic orogenic belts is commonly accepted as evidence for sea-floor spreading and subuction, respectively. Many workers, however, have accepted that the mafic volcanic sequences of greenstone belts orginate in proto-oceanic (e.g. Windley, 1976) or marginal basin settings (e.g. Tarney et al., 1976), and evidence for the occurrence of complete or partial ophiolite assemblages in Archean greenstone belts from South Africa, Wyoming, and northwestern Canada was presented by de Wit and Stern (1980), Harper (1986), and Helmstaedt et al. (1986). Whereas this supports Archean sea-floor spreading, arguments for Archean subduction have been of a more theoretical nature (e.g. Nisbet and Fowler, 1983), as surface occurrences of eclogites of undisputed Archean age have not been reported. Workers on mantle nodules from kimberlites, however, have found that the origin of a number of xenolith and xenocryst types can be explained by subduction of oceanic lithosphere. These include certain <u>eclogites and grospydites</u> which may have been derived from subducted metabasites and rodingites (e.g. Helmstaedt and Carmichael, 1978; Walker, 1979; Ater et al., 1984; MacGregor, 1985), <u>alkremites</u>, derived from Al-rich sediments (Exley et al., 1983) or black wall-chlorite alteration around metaserpentinites (this paper), <u>grossular inclusions in diamonds</u> (Sobolev et al., 1984), <u>peraluminous garnet-kyanite rocks</u>, derived from pelitic sediments (Helmstaedt and Hall, 1985), <u>diamondiferous low-Ca garnet harzburgites and dunites</u>, derived from graphite-bearing metaserpentinites (Schulze, 1986), and <u>green garnets related to wehrlites</u>, derived from uvarovite-bearing serpentinites (Schulze, this volume). Such nodules, if indeed of Archean age, represent part of the complimentary mantle sample of rocks exposed in Archean shields and constitute direct evidence for subduction in the Archean rock record.

Although it is still a matter of debate whether the higher heat loss from the Archean Earth required "faster spreading" or "more ridge" (Hargraves, 1986), it is likely that the Archean was characterized by relatively fast spreading rates and subduction of relatively young oceanic lithosphere (e.g. Abbott and Hoffman, 1984; Abbott, 1984). As such conditions would favour relatively shallow or low-angle subduction, we propose that the Archean lithosphere beneath the southern African craton was formed by lateral underplating of subducted oceanic lithosphere. In a regional plate tectonic synthesis, Light (1982) showed that the Zimbabwean and Kaapvaal cratons may have been separated by more than 1000 km of oceanic crust and that this crust was subducted beneath the Kaapvaal craton. To explain the presence of Archean subducted rocks among the mantle sample from kimberlites of the Kaapvaal craton, we envisage that this and earlier subduction zones were shallow-dipping and that the entire craton was repeatedly underplated by oceanic lithosphere.

The post-Archean evolution of the continental lithosphere involves a change from a regime of rapid spreading and predominantly shallow, low-angle subduction to more normal plate tectonics. Low-angle subduction, the dominant process during the formation of the Archean lithosphere, became an exception, restricted to episodes of rapid plate convergence and/or subduction of low-density crust. As it can be shown that such episodes have preceeded some of the major kimberlite events within and on the margins of stable cratons (Helmstaedt and Gurney, 1982), low-angle subduction is held responsible for the intraplate processes that modified the upper mantle, controlled kimberlite distribution, and eventually triggered the kimberlite eruptions. The post-Archean metasomatic overprint recognized in many upper mantle nodules and the formation of the megacryst suite may be related to these episodes.

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