An overview of diamond exploration in the North China Craton

Michael Michaud
China Diamond Corp.1724 Hyde Park Road,London, Ontario,N6H 5L7 Canada

Keywords. Diamond exploration, kimberlite, North China Craton

1 Introduction

China's history of diamond exploration and production extends over 40 years, initially concentrating on the discovery of alluvial deposits and later the kimberlitic sources. Diamond production from China currently totals 90,000 carats/annum from one kimberlite diamond mine, namely China Diamond Corp.'s 701 Changma Mine in Shandong Province that has operated for the past 34 years. Previously, between 1987 and 2002, additional kimberlite diamond production came from the Wafangdian Mine in Liaoning Province, producing approximately 60,000 carats/annum. To date, over 20 diamondiferous kimberlite deposits have been discovered, several of which have been mined on a very small scale.

China is underlain by three large Archean cratons, namely the North China Craton, also known as the Sino-Korean Craton, and the Yangtze and Tarim Cratons. In all three of the cratons, several alluvial diamond deposits have been discovered; however, to date, only two diamondiferous kimberlite deposits have realized commercial production, those being located in the North China Craton (Fig. 1). This is due in part to the difficult terrain, lack of adequate access, and extensive soil cover in the Yangtze and Tarim Cratons, comparatively.

The North China Craton is considered prospective for diamonds due to the fact that Ordovician-aged kimberlites have traversed the Archean mantle with the potential to be laden with diamonds. However, numerous tectonic episodes have modified the underlying lithosphere since the Ordovician emplacement of the kimberlites, so that selected geophysical data would be misleading as a prospecting tool to identify regions with cratonic physical properties.

2 Regional geology

All the so-called cratons in China are not strictly cratons; since they have undergone multiple tectonism since the late Paleozoic. The tectonic framework of China is dominated by three global orogenic systems, the Central-Asian or Paleo-Tethyan, the Circum-Pacific and the Tethys–Himalaya systems. The Mesozoic–Cenozoic Circum-Pacific orogenic belt in eastern China and the Tethys–Himalaya system in southwestern China are the products of the subduction of the Pacific Ocean floor beneath China, and the indentation of the Indian continent into Eurasia, respectively. The area is underlain by numerous fold belts that are dominantly products of subduction and accretion of oceanic complexes, and were the focus of deformation in Paleozoic–Mesozoic cratonic collisions during final ocean closures.

The North China Craton is comprises early Archean to Early Proterozoic basement rocks overlain by Middle Proterozoic to Cenozoic cover. The three major cratons in China (North China, Tarim, and Yangtze) underwent at least three orogenies during the Archean, widely-termed the Qianxian (ca. 3.2 Ga), Fuping (ca. 2.8 Ga), and Wutai (ca. 2.5 Ga). During these orogenies, rock units experienced extensive greenschist to granulite facies metamorphism, intensive migmatization, and widespread magmatism. Subsequently, the Precambrian sequences were locally uplifted and exposed, especially along the margins of the North China Craton during a series of Phanerozoic orogenies. The primary orogenies are defined as between 600 and 405 Ma as Caledonian, 405 and 270 Ma as Variscan, 270 and 208 Ma as Indosinian, 208 and 90 Ma as Yanshanian, and <90 Ma as Himalayan. These collisions may have coincided with development of the Tanlu fault system, extending over 4,000 kilometers, which was continually active along the eastern margin of China during the middle and late Mesozoic Yanshanian orogeny. The Tanlu fault is considered by many to have resulted in a 500 kilometer displacement of the Wafangdian Mine (Fuxian kimberlite field) from the 701 Mine (Mengyin kimberlite field). In the Yanshanian (210–90 Ma) and Himalayan (<90 Ma), the oblique subduction of the Izanagi–Pacific basin plates under the eastern edge of China led to the formation of the NNE-trending Yanshanian magmatic belts and faults along the Pacific continental margin, considered to one the of the most important metalogenic orogenies in China.

A comprehensive study using "4-D lithosphere mapping" was completed by Griffin, et. al. in 1997. The main results of this study are summarized as follows:

- The Lithosphere-Asthenosphere Boundary about 500 Ma ago was at ~180-200 kilometers deep;
- An Archean lithosphere ~200 km thick existed under the eastern Sino-Korean Craton up to Late Ordovician allowing the emplacement of diamondiferous kimberlite pipes and dikes;

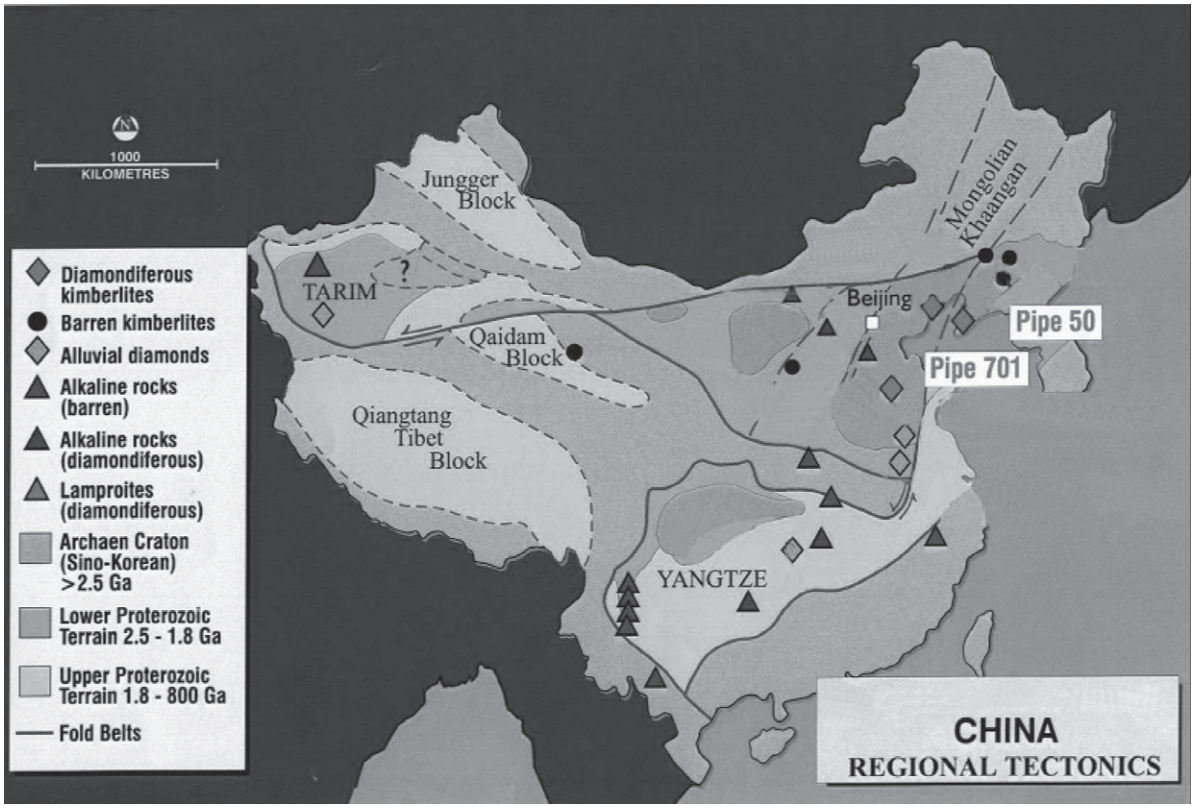

Figure 1: Simplified regional tectonic map of China showing geographical extent of the three cratons, namely the North China, Yangtze and Tarim cratons (modified from Redox Minerals website).

- Geophysical data show a present-day thin lithosphere (60 -120 km) and high geothermal gradient under the North China Craton implying the replacement of 80 - 140 kilometer thick section of the Archean lithosphere with "oceanic" lithosphere since the Ordovician;
- The replacement of the lithosphere is interpreted to be a result of thermal erosion of the lithosphere linked to two episodes of basin development and rifting associated with subduction.

3 Kimberlite emplacement

The emplacement of the kimberlite pipes and dikes in the North China Craton occurred at several times, ranging from 450- 480Ma in age to a much later Tertiary age, the former being diamondiferous and include the kimberlites at the 701 Mine and Wafangdian Mine. The kimberlitic bodies appear to be related to deep mantle structures that have been further controlled by near-surface crustal faults. Many of the kimberlite pipes and dikes in the area occur at or near the intersection of major west-northwest and north-northeast trending geological structures along the Tanlu Fault trend. The kimberlites form both narrow and often discontinuous dikes that are connected to larger, more ellipsoidal pipes (Figure 2).

The kimberlitic bodies are typically characterized by porphyritic kimberlite with a matrix of serpentinized olivine and phlogopite and phenocrysts of olivine, biotite and pyrope. The accessory minerals include ilmenite, chromite, and chrome diopside. The breccia rock fragments include local country rock inclusions of limestone and gneiss, and mantle eclogite and garnet lherzolite. The mineral resources for different deposits, and for that matter between different pipes within a deposit, varies considerably in grade, diamond size distribution and quality, as indicated in Table 1.

4 Discussion

The North China Craton is considered prospective for diamonds due to the fact that Ordovician-aged kimberlites have traversed the Archean mantle with the potential to be laden with diamonds. However, numerous tectonic episodes have modified the underlying lithosphere since the Ordovician resulting in the replacement of an approximately 80-140 kilometer thick section of the Archean lithosphere with "oceanic" lithosphere. The Ordovician is related to several episodes of basin development and rifting associated with plate subduction.

The thinning of the crust in the North China Craton has important implications for diamond exploration. Geo-

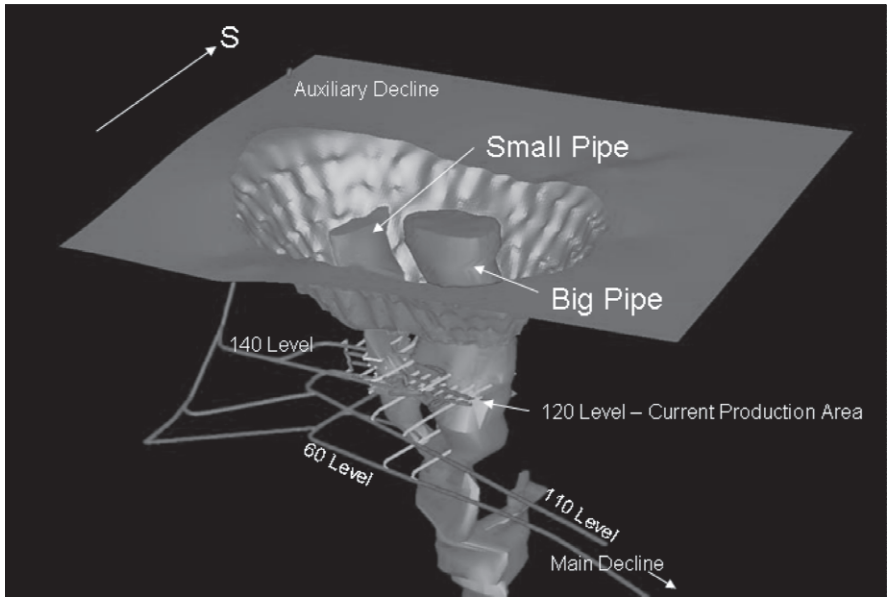

Figure 2: Three dimensional view of the 701 Mine showing distribution and geometry of kimberlite pipes and mine workings.

Table 1: Mineral resources from selected kimberlite diamond deposits in North China Craton

Deposit	Location	Initial Mineral Resource		Approximate Value (US$/carat)	Status of Project
		Tonnage (x 1,000)	Grade (carats/t)		
701 Mine	Shandong Province	4,292	1.10	$40/carat	Since 1970 produced 1.7 million carats
Wafangdian Mine	Lioning Province	9,400	0.40	$125/carat	Production 1987 to 2003
702 Deposit	Shandong Province	41,000	0.13	$100/carat	Feasibility Stage

Notes: Data from Chinese geological archives. Mineral resources reported >0.2mm cutoff size.

physical data would be of little use as a prospecting tool to identify regions with cratonic physical properties, and also, in the determination of the age of kimberlites that had the potential to "tap" Archean lithosphere. Great care must be taken to unravel the timing and nature of these tectonic events in order to assist any exploration efforts.

Reference

Griffin WL, Andi Z, O'Reilly SY, Ryan CG (1997) Phanerozoic evolution of the lithosphere beneath the Sino-Korean Craton. In: Mantle Dynamics and Plate Interactions in East Asia (Flower, M., Chung, S.L., Lo, C.H. and Lee, T. Y. eds) American Geophysical Union Spec. Publ., in press 7/96