The Chromite potential of Afghanistan

Introduction

Afghanistan has a complex geology due to it position on the junction between the Indo-Pakistan and Eurasian crustal plates. Its geology is composed of a series of terranes that broke away during the Triassic, at around 250 million years ago, from the main Gondwana supercontinent before colliding, with each other or, with the Eurasian plate. Ultimately, all the terranes became successively accreted onto the southern margin of the Eurasian plate. The accretionary events started in the Cretaceous and have continued until recent times. At some stage in the early Cretaceous there is evidence of a collision of one of these blocks, the Farad block, with the Eurasian plate, along the Herat fault zone, which marks the middle Afghanistan suture. Shortly afterwards, the Helmand block collided with the Farad block to form the central Afghanistan massif. The exotic Kabul block was accreted against this massif and finally the collision of the Indo-Pakistan plate against these blocks formed the main mountain ranges of the Hindukush and the Himalayas. The lines of the sutures between the accreted blocks are marked by remnants of the oceanic crust, which formerly underlay the Palaeotethys and Tethys oceans and these are now seen as lines of ultramafic rocks of ophiolite type (Figure 1).

Chromite in Afghanistan

Volin (1950) evaluated ten known chromite bodies in the Logar ultramafic body, using surface mapping and sampling and a limited programme of shallow diamond drilling. He also calculated reserve figures based on the results of this drilling. Hunger (1955a and b) recorded two further chromite localities. Siebdrat (1971) undertook further surface mapping of the ultramafic rocks of the Logar Valley, and during this study he identified 18 chromite localities in the Logar ophiolite (Figure 2).

Abdullah (1980) in his comprehensive review of the geology and mineral occurrences of Afghanistan catalogued about 15 areas of chromite mineralisation scattered throughout the country, most in the Logar Valley, south of Kabul. The other areas include Jurgati in Parwan Province, Werek in Logar Province, Sperkay and Shandal in Paktia Province. In addition, minor occurrences of chromite in eluvial deposits and of small chromite lenses in situ were reported by Abdullah in Kandahar Province associated with Early Cretaceous ultramafic rocks. Chromite grains were also observed in concentrates from Kandahar Province collected by the Russian reconnaissance surveys.

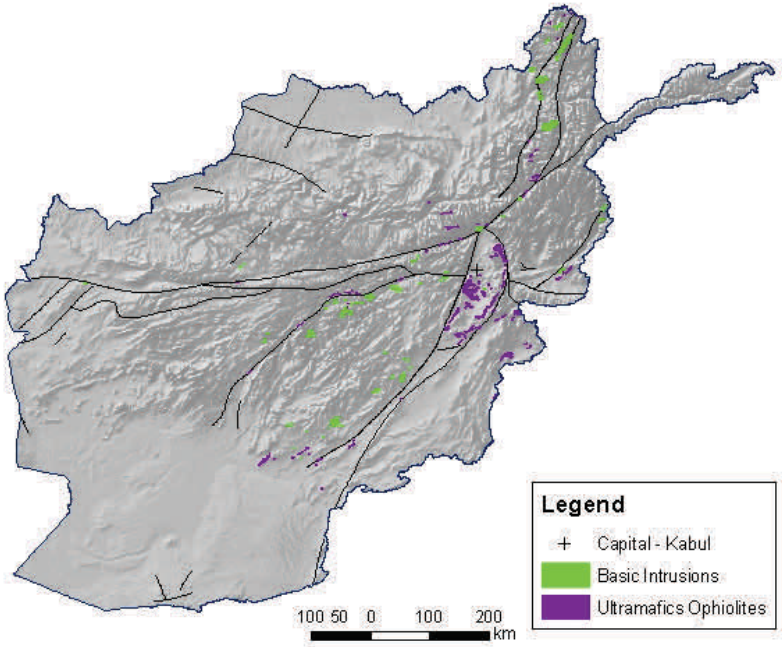

Figure 1. Tectonic sketch of Afghanistan showing the major sutures and the location of ophiolitic rocks and basic intrusions on a shaded relief background.

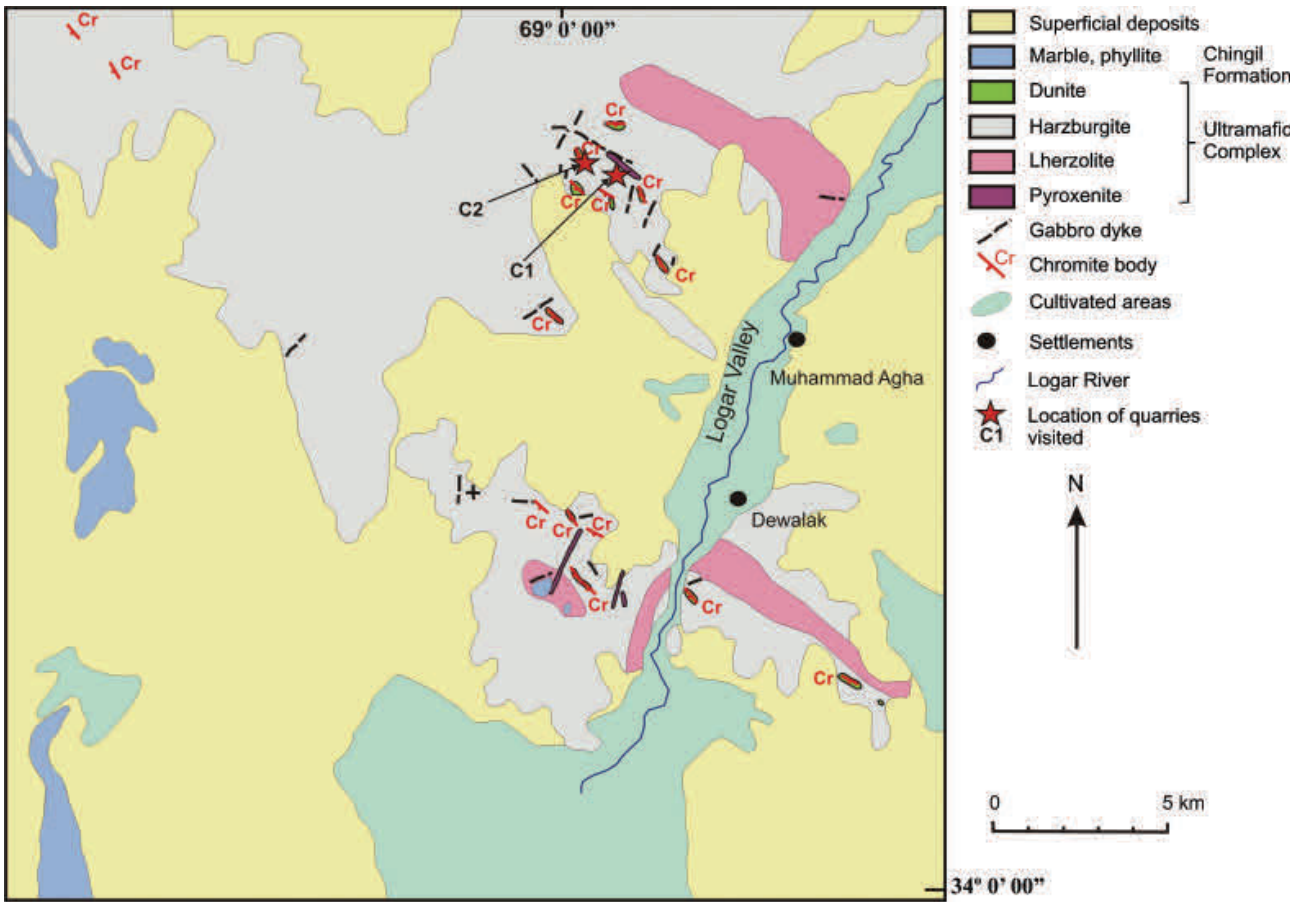

Figure 2. Chromite occurrences in the Logar area showing the association of the chromite bodies with lenses of dunite within the harzburgite (modified after Siebdrat, 1971. Visited sites C1 and C2 are from Benham et al., 2009).

The Logar Ophiolite

The largest and most well known chromite deposits in Afghanistan are situated in the Logar valley in the Muhammed Agha District about 35 km south of Kabul. The Logar ophiolite complex has an approximately ellipsoidal outcrop, elongated in a north-westerly direction, about 65 km long and up to 45 km wide. The external contacts are mostly tectonic: the steep-dipping north-south Pagman Fault forms the western contact, while to the east and south-east the complex is bounded by the Altimur Fault. To the north the Abparan Thrust separates the allochthonous ultramafic rocks form the autochthonous rocks of the Kabul Block.

The largest part of the ophiolite comprises ultramafic rocks in a sequence up to about 2800 m thick. The basal part comprises about 2400 m of dunite and subordinate harzburgite, overlain by a thick pyroxenite about 200 m thick with minor intercalated dunite at its base. This passes up into a thin unit of troctolite and pyroxenite, passing up into a 50 m thick gabbronorite. The chromite bodies occur predominantly in the harzburgite within small dunite pods according to Siebdrat (Figure 2).

Resource Assessment

The chromite deposits in the Logar Valley (Figure 2) occur in two principal groups about 10 km apart, all except two on the west side of the valley. The northern cluster of deposits is located within 5 km to the north-west of Muhammad Agha. The southern cluster of deposits occurs in the vicinity of Karez-Sha-Ghazi, about 10 km south of Muhammad Agha. All of these deposits are within easy reach of Kabul via the surfaced Kabul-Gardez road.

These deposits were studied in detail by the U.S. Bureau of Mines (USBM) in 1949-50. Volin (1950) undertook investigations aimed at estimating reserves of chromite ore of suitable quality for the prevailing market conditions. No exploration for additional deposits was carried out. Subsequent reassessment by the German Geological Mission (Siebdrat, 1971) increased Volin's estimates by a significant amount, but it is unclear whether this was based on additional drilling or new geophysical data.

The chromite deposits consist of massive lenses, pods and irregular-shaped masses of dominantly massive chromitite. Textural variations are few with minor development of patchy 'leopard skin' type ores. The largest deposit (no 5 of Volin) comprises two lenses, one 97.5m long and up to 10 m wide and the other 65 m long and up to 5 m wide. Most of the other deposits are considerably smaller. The margins of the chromite bodies are sharp, knife-edge and generally highly irregular in form, rarely planar. Immediate wallrocks are generally serpentinised and show development of a close

-spaced planar fabric/fracturing parallel to the contact with the chromitite.

The USBM programme of mapping and sampling outcrops, trenching in shallow overburden, sampling by shallow percussion drilling and the drilling of 27 diamond drill holes with an aggregate length of 975 m. The diamond drilling tested three of the largest deposits on surface and a small high grade deposit, all in the northern cluster of deposits. Volin estimated a total reserve of 181,000 tonnes, concentrated in three deposits (1, 2 and 5). Of this about 15% (27 000 metric tonnes) is high grade metallurgical ore with 55.9% Cr_2O_3 and Cr:Fe ratio of 3.5:1. The remainder of the reserve contains less than 45% Cr_2O_3 and high levels of Al_2O_3. 92% of the total reserve occurs in the three largest deposits (2, 5 and 7), and, of these, only deposit 2 contains high-grade ore.

Composition of Logar Chromite Ore

Most of the material exported from Afghanistan is hand picked on site and the Afghanistan Geological Survey has sampled this hand sorted ore. Based on 18 sample analyses collected from various sites in Logar and elsewhere in the Kabul block. The analyses were performed by AGS staff supervised by GTZ using the NITON portable-XRF analyser and gave a median content of 35.56% Cr (equivalent to 52% Cr_2O_3) and a Cr/Fe ratio of 4.2 (Table 4). The statistical distribution is lognormal and slightly lower than Volin reserve estimate given above, but higher than the median grade of 44% Cr_2O_3 for minor podiform deposits given by Albers (1986).

Platinum Group Element potential of the Logar Area

Benham et al. (2009) have published the only recent analyses of Platinum Group Elements in rocks from the Logar Complex. Concentrations of PGE in the Logar chromitites are low with maxima of 6.5 ppb Pt and 5.5 ppb Pd. Rh values are relatively high, with two samples exceeding 10 ppb. In dunites, Pt and Pd values are generally <10 ppb, although one sample LGR 012 contains the maximum reported values of 11.3 ppb Pt and 9.4 ppb Pd. The pyroxenite samples have relatively high Pt values with an average of 13 ppb, whilst they have very low Pd and Rh values. However, these observations are based on limited data and further sampling would be needed to identify any significant patterns in the data.

Table 4. Median and quartile range of Chromium and Iron in Chromitite samples from Logar

Element	Median (%)	25th Percentile	75th Percentile
Cr	35.56	31.40	37.41
Fe	8.45	8.18	9.65

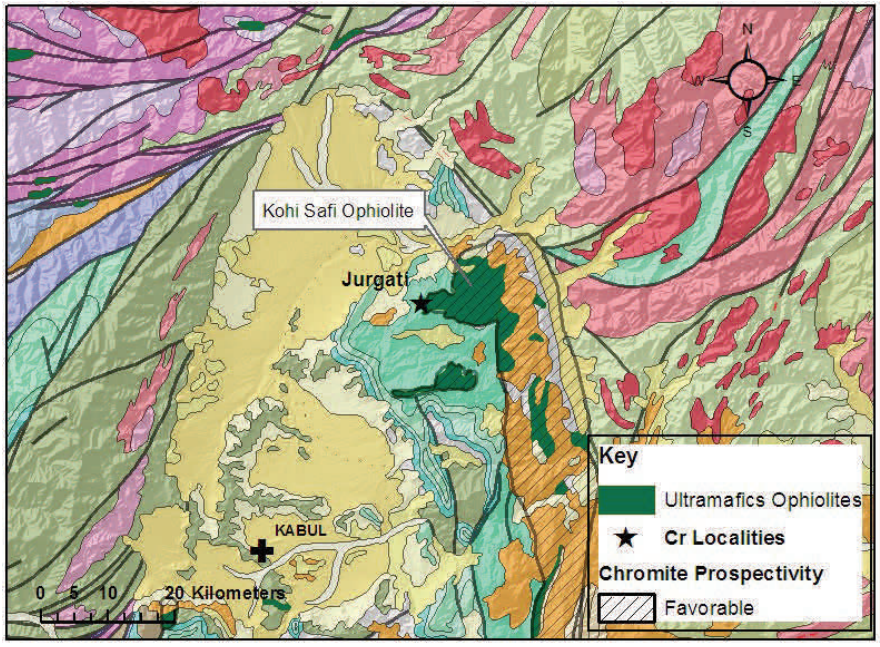

Figure 3. Geological map of the area north of Kabul showing the Jurgati locality and favourable prospective areas from Peters et al., (2007).

North Kabul Block

North-east of Kabul another ophiolite complex has been obducted onto the Kabul Block and is named as the Kohi Safi Complex after the district in which it is found (Figure 3). The Jurgati chromite occurrence is located in Parwan province about 45 km north-northeast of Kabul near the peak of Sarpokhi Ghar within the Complex. The mineralisation is 20 m by 30 m in size and found in the western part of an Eocene peridotite (Denikaev and others, 1971). Chromite mineralisation and small scale mining has been reported in 2008 from this area by Bräutigam (pers. comm.) but its areal extent is unknown. Compared to the Logar complex, Kohi Safi is about ¼ the size but it has been poorly studied so that economic potential is difficult to assess.

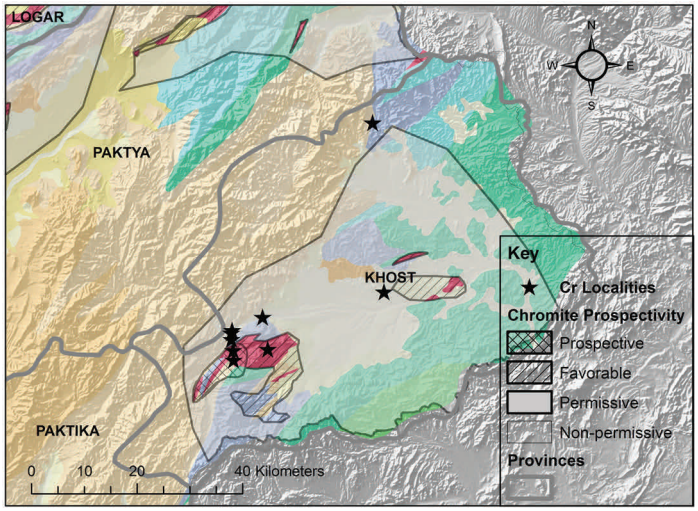

Figure 4. Cr localities in Khost province, prospective areas from Peters et al., (2007) on a background of the geological map and shaded relief from the same source.

Khost and Paktia

At the Sperkay chromite occurrence just west of Teragharay near the border with Khost Province, ten massive chromite bodies are found in Eocene peridotite (Figure 4). The bodies are as much as 110 m long and 1 to 10 m thick. They assay from 43.11 to 53.48% Cr_2O_3 and from 5.57 to 7.23% Fe. The Shandal (Shodal) occurrence is located south-west of Teragharay and about 1 km south of Sperkay. There are 34 known chromite-bearing lenses ranging from 3 m to 40 m long and 0.2 to 0.4 m thick and thin veinlets with disseminated chromite; all occur in Eocene peridotite. The massive chromite lenses have minor olivine grains and assay 44.36% Cr_2O_3. Nitikin and others (1973) speculate that resources are 4,002 t.

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Summary of the Chromite and PGE potential of Afghanistan

- **A large number of small deposits have been worked at surface**
- **There is a large potential for the discovery of further deposits at surface and at deeper levels**
- **The PGE potential has been largely untested but grains of PGE minerals have been discovered**
- **Exploration for PGE should be focussed on areas with sulphide minerals**

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