6.1

CHAPTER 6. ATLAS OF MORPHOLOGY OF KONDER PLATINUM MINERALS

On page 85:
6.1. Isoferroplatinum: elongated cubic crystal with cavities – casts after silicate grains.
15 x 6 x 4 mm, 5.2 g.
Gokhran of Russia.
Photo: Michael B. Leybov.

This part reports morphological diversity of the placer-forming platinum mineral individuals and aggregates, their relatively large segregations (> 3 mm) and crystals, and other most remarkable precious metal minerals of the Konder Massif. The part organized as atlas. The atlas is based on the representative collection of photos, showing this diversity accompanied by comments highlighting genetic aspects reported in Chapter 5. They emphasize a nature of specific morphological features of certain sample.

Photos of relatively large placer-forming platinum mineral grains of the Pt > Ir, Pt > Os, and Pt > Pd mineralogical and geochemical types (*Figs.* 3.3–3.8) were selected for the atlas. Minerals of the magmatic and magmatic-fluid-metasomatic Pt types constitute fine fraction (Tables 3, 4) in both placers and primary ores and therefore are not shown in the atlas. Their representatives from cumulative and re-crystallized dunite are shown in *Figs.* 5.10, 5.22a,b,c. Fine and medium size Pt > Ir-, Pt > Os-, and Pt > Pd-type placer-forming platinum minerals (Tables 3, 4) as anhedral, subhedral, and euhedral individuals and grains with various abrasion are shown among panning platinum (*Fig.* 0.3).

Placer-forming PGM of the fluid-metamorphic Pt > Ir, magmatic-fluid-metasomatic Pt > Os, and magmatic-fluid-metasomatic Pt > Pd-types are divided into characteristic morphological groups in the atlas. The morphology of the placer-forming platinum mineral individuals and aggregates from all groups is determined by their ontogeny (*Figs.* 5.11, 5.14–5.25) and degree of abrasion (or more exactly, degree of attrition). Ore minerals were abraded in the slope and alluvial sediments. On the slopes and in the alluvium, heavy grains of placer-forming platinum minerals are slow-moving, whereas light and harder grains of silicate minerals can be transported in water flow and abrade the surface of platinum minerals. Distance of the placer-forming platinum mineral grains from the source is caused by their transportation in the rock fragments, from which ore minerals are released after crushing and transportation of loose sediments on the slopes or valley bottoms as a result of tectonic rise of the territory or lowering of the sea level.

Decreased sample density in comparison with ideal density of isoferroplatinum Pt_3Fe (ρ ~ 18.5 g/cm^3), enriched in native platinum admixtures (Pt, Ir, Pd, Rh, Fe) (ρ ~ 19.5 g/cm^3) or admixture-free native platinum (ρ ~ 22 g/cm^3) testifies to the inclusions of lighter constituents, oxides, silicates and sulfides, as well as caverns.

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6.16. Well-rounded placer-forming platinum mineral nugget with dense disseminated chrome spinel.
Height 2.74 cm, density 8.54 g/cm^3.

6.17. Rounded placer-forming platinum mineral nugget with rare chrome spinel inclusions. Height 2.09 cm, density 15.36 g/cm^3.

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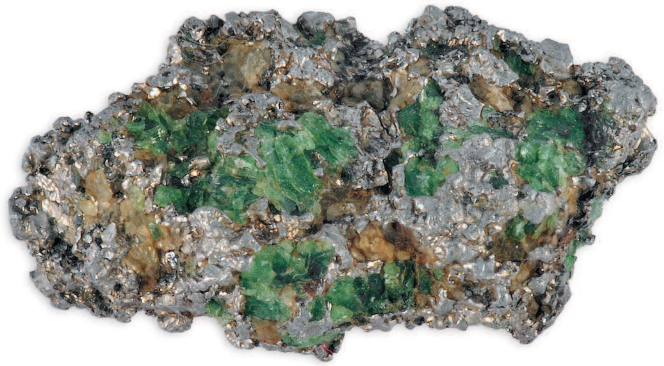
6.18. Rounded placer-forming platinum mineral nugget with chrome spinel inclusions. Dark brown film of iron hydroxides in on the nugget surface.
Width 2.45 cm, density 13.80 g/cm^3.

Brown-black film or crust of iron oxides is observed on the surface of some placer-forming platinum mineral aggregates (*Figs.* 3.11, 6.18). Such samples are the most frequent in the areas with lithified alluvium (for example, they were found in the Konder watercourse between EL 160 and 176). Alluvium is cemented by the heavy minerals, magnetite, hematite, and goethite (limonite).

6.2. Morphology of Pt > Os-type platinum minerals intergrown with clinopyroxene

Large placer-forming platinum mineral aggregates intergrown with diopside are much rarer than those intergrown with forsterite and chrome spinels. The Pt > Os-type placer-forming platinum mineral intergrown with clinopyroxenes (*Figs.* 6.19, 6.20, 6.22) and Pt > Pd-type placer-forming platinum mineral intergrown with diopside (*Figs.*

6.19



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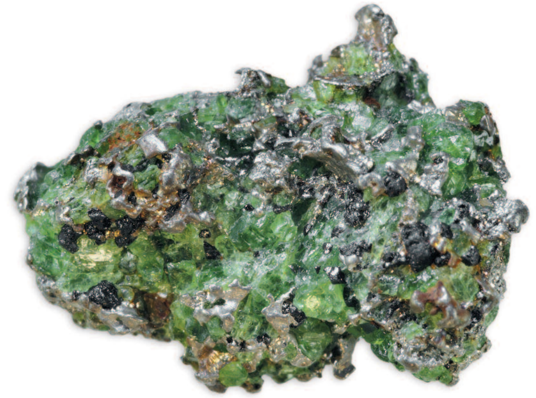

6.19. Poorly rounded fragment of placer-forming platinum minerals, diopside, and forsterite (yellow) aggregate. Width 1.35 cm, density 12.71 g/cm^3.

6.20. Poorly rounded fragment of placer-forming platinum minerals and diopside aggregate with disseminated chrome spinel.
Width 1.10 cm, density 13.07 g/cm^3.

6.21. Aggregate of Pt > Pd-type placer-forming platinum mineral and chrome diopside. Fine induced striation resulted from compromise growth with chrome diopside is seen on the placer-forming platinum mineral surface.
Width 0.30 cm, density 16.81 g/cm^3.

6.22. Poorly rounded fragment of placer-forming platinum mineral and diopside aggregate. Width 0.31 cm, density 13.21 g/cm^3.

6.23. Fragment of Pt > Pd type placer-forming platinum mineral with diopside. Width 0.4 cm.

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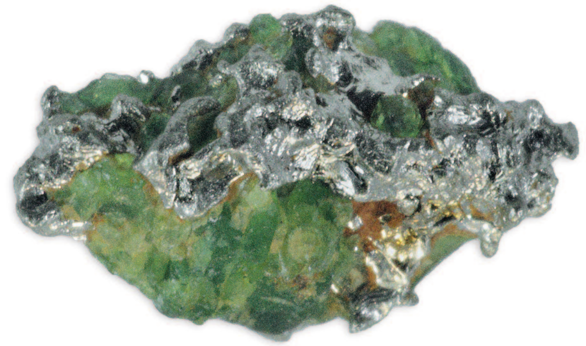

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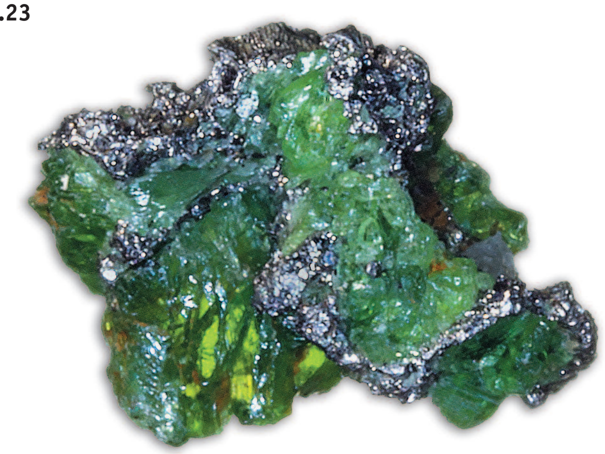

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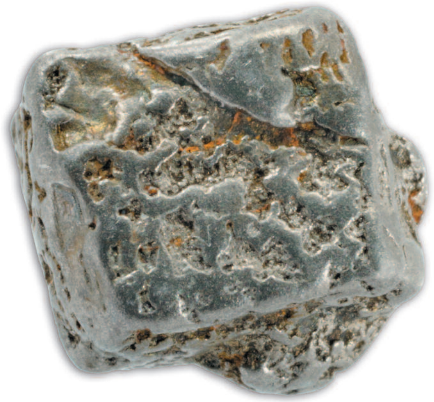

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6.43. Cascade twin on (111), consisting of four placer-forming platinum mineral crystals. Width 0.77 cm, density 18.69 g/cm^3.

6.44. Semirounded penetration twin on (111) of cubic placer-forming platinum mineral crystals. Width 0.62 cm, density 18.55 g/cm^3.

6.45. Semirounded penetration twin on (111) of cubic placer-forming platinum mineral crystals. Width 0.75 cm, density 18.32 g/cm^3.

6.46. Rounded penetration twin on (111) of cubic placer-forming platinum mineral crystals. Width 0.98 cm, density 18.44 g/cm^3.

The contact twins, formed according to the spinel law, whose individuals are characterized by substantially developed octahedral faces (*Figs.* 6.31, 6.32), are occasionally observed. Penetration twins on (110), formed according to the fluorite or spinel law, whose habit is determined by the relative development of cubic {100} and octahedron {111} faces, and alignment of the twin subindividuals are typical (*Figs.* 6.33, 6.34–6.38). Intergrowths of more than two cubic crystals are also present (*Figs.* 5.21d,e; 6.39–6.43).

Twins with various degree of roundness reveal an unusual habit (*Figs.* 6.44–6.46).

6.3.3 Sculptures of layered growth

The placer-forming platinum mineral crystals most frequently grow as flat layers. Micron-high steps of layered growth are observed on both germs (*Fig.* 5.20b) and most grown crystals, as seen on the scanning electron microscope images (*Figs.* 5.21a,c,d,e,f; 5.22, a,g,h; 5.24b,c). Thicker growth steps are observed microscopically (*Figs.* 6.33, 6.47, 6.48) and less frequent with naked eye (*Figs.* 6.24, 6.49–6.52).

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6.47. Complex cascade penetration twin on (111) of placer-forming platinum mineral crystals with fragment of green augite-diopside (top). Width 0.87 cm, density 17.39 g/cm^3.

6.48. Cascade penetration twin on (111) of cubic placer-forming platinum mineral crystals with layered growth figures on faces. Width 0.45 cm.

6.49. Penetration twin on (111) of cubic placer-forming platinum mineral crystals with mosaic surface and layered growth steps. Width 0.95 cm, density 17.37 g/cm^3.

6.50. Penetration twin on (111) of cubic placer-forming platinum mineral crystals with pronounced flat growth layers on faces. Width 0.49 cm, density 17.97 g/cm^3.

As shown by the placer-forming platinum mineral aggregates, the layered growth of individual faces continues to the contact with the faces of the other crystal. Then, the geometric selection, aiming at search of the most favorable position of crystal faces (probably with regard to moving mineral-forming fluid), takes place. Therefore, some crystals reveal a crystallographic growth, whereas others are grown under reduced conditions or their growth is terminated (*Figs.* 5.21d; 6.47–6.52).

Sometimes, divergent growth surfaces of the placer-forming platinum mineral crystals and twins are observed. The compromise growth surface is lustrous wavy-smooth (*Fig.* 6.53) or with typical induced striation (*Fig.* 6.54).

The layered growth implies concentric zoning of the placer-forming platinum mineral crystals that is recorded in the trace PGE composition and variable concentration of Fe and Cu. This is reliably determined with electron microprobe analysis of the sections of the placer-forming platinum mineral individuals.

The layered growth sculptures are retained under reduced growth conditions of the crystals and their clusters between silicates and oxides (*Figs.* 5.22h; 6.49, 6.55).

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6.60. Multi-terminated cubic crystal of placer-forming platinum minerals with rough blocky-mosaic surface, rare morphological type.
Width 1.80 cm, density 14.03 g/cm^3.

6.61. Complex cascade twin on (111) of cubic placer-forming platinum mineral crystals.
Black crystals are Cr-bearing magnetite. Width 0.60 cm.

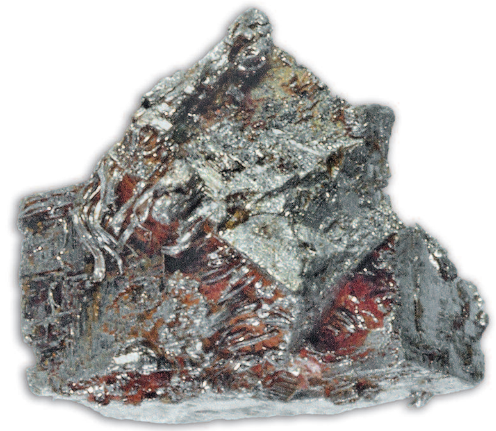
6.62. Penetration twin on (111) of rough blocky cubic crystals of placer-forming platinum minerals with indications of initial mutihead growth on some faces. Width 1.01 cm, density 15.64 g/cm^3.

6.63. Penetration twin on (111) of cubic placer-forming platinum mineral crystals with growth figures on faces.
Width 0.35 cm, density 17.06 g/cm^3.
(a–b) two sides of the twin.

6.63a

6.63b

6.64



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6.64. Penetration twin on (111) of cubic placer-forming platinum mineral crystals overgrown by filament crystals formed during multi-terminated growth. Width 0.20 cm.

6.65. Rough cubic crystal of placer-forming platinum minerals with blocky surface; separate blocks show indications of skeletal growth. Interstices between them are filled by weathered yellow-brown silicate. Width 0.30 cm.

6.66. Cubic crystal of placer-forming platinum minerals with rounded overgrowths, "warts", which are deformed bunches of filament subindividuals partly abraded in placer. Width 0.56 cm, density 19.04 g/cm^3.

6.67. Near-parallel intergrowth of strongly elongated along [100] cubic placer-forming platinum mineral crystals. Scanning electron microscope image. Part of this sample is shown in *Fig.* 4.17h. Width 0.60 cm.

6.67

6.3.4. Sculptures related to skeletal and multi-terminated growth

Skeletal shapes are typical as results of the multi-terminated crystal growth. They frequently arise on the placer-forming platinum mineral crystal surface as a result of irregularly growing faces (*Fig.* 6.22c–f). Subindividuals on the crystal faces are cubic or tabular (flattened pseudo-hexagonal prism) (*Figs.* 6.56, 6.57).

Typical crystals resulted from the multi-terminated growth are shown on *Figs.* 6.58–6.60. During growth, the crystals are frequently separated into