Funding annex · World Bank

IFC / MIGA

QuantumSpectra · 2026-11-25 13:17 UTC · pillars: mining · twin · annex to the investor one-pager (0x3615025815ec82…)

What we request

Private co-finance and guarantees for renewal bonds and processed-product mining

We fuse hyperspectral imaging, satellite feeds, quantum-enhanced AI, structural simulation and custodial blockchain finance into one platform for sustainable agriculture, earthquake-safe urban renewal and auditable public services in Türkiye. Every measurement, contract, pickup and payment is SHA-256 anchored, so citizens, municipalities and funders look at the same evidence.

Pillar fit

Urban Digital Twin & Disaster Scenarios · **demo live · simulated data**

A 3D simulation platform for sustainable urban planning: hyperspectral material health on every member, OpenSees non-linear analysis (time-history + modal pushover), a TBDY 2018 strength-margin map, retrofit what-if scenarios and council-ready, hash-anchored reports.

- Real Turkish strong-motion records (Düzce, Kocaeli…) scaled to the TBDY target spectrum
- FRP · steel jacket · shear wall · base isolation vs demolish-and-rebuild feasibility
- Crack-growth alerts, weekly twin summary, PDF archive with council receipt stamps

7 strong-motion records · **0** timeline photos · **0** crack-growth alerts · **0** margin reports sent · https://spaceseax.tech/twin

Sustainable Mining — High-Value Rare & Strategic Elements · **live · reference prices**

Hyperspectral SWIR mineral mapping, kriged resource inventory, cut-off and NPV economics, tailings / acid-mine-drainage risk and a rehabilitation score; flowsheets that sell processed product — not raw ore — for rare earths, lithium, antimony, tungsten, graphite and boron.

- Supply-risk × economic-importance matrix aligned with the EU Critical Raw Materials list
- Price-feed-linked NPV; planners alerted automatically when a project flips sign
- Province reports, settlement-buffer zoning verdicts adopted via Justice attestations

16 research sites · **0** engineered studies · **11** strategic commodities modelled · **1** province reports · https://spaceseax.tech/mining

Live KPIs — read from the platform database at generation time

53 hyperspectral / satellite scans	**56** safety & carbon certificates	**727 kg** farm-to-fork traded · 10 orders	**6** cooperatives on the market
0 CSA households · treasury 0 TRY	**117.2 M TRY** renewal bond capital · 19 cases	**36** earthquake-safe units renewed · 36 high-risk retired	**19** rural health screenings · loop closure 0.0 %
16 mining research sites · 0 surveys	**0** quality QR batches	**0** shopper ratings · avg —/5	**6.6 M TRY** social-housing donations · 7 sites · 41 citizen claims

Spectral, health and mining values are SIMULATED research-grade outputs until live sensors stream; wallets and bonds run on simulated TRY; blockchain anchors are SHA-256 hashes stored in MongoDB.

Evidence register — anchored records you can verify

Pillar	Evidence	Record	Date	Anchor / hash	Verify
Urban Digital Twin	Weekly twin summary	week 2026-11-16 · 63 below · 0 alerts · 0 photos · 0 recipients	2026-11-23	b82421d2-f3a1-49c8…	/twin
Urban Digital Twin	Weekly twin summary	week 2026-11-16 · 63 below · 0 alerts · 0 photos · 4 recipients	2026-11-23	a74c396d-b3dc-4328…	/twin
Urban Digital Twin	Weekly twin summary	week 2026-11-09 · 63 below · 0 alerts · 0 photos · 0 recipients	2026-11-16	2e793f27-d4e2-47c2…	/twin
Urban Digital Twin	Strong-motion record	Düzce 1999-11-12 · Düzce (DZC) · E-W 270 · PGA 0.535 g · Mw 7.2	1999-11-12	PEER NGA-West2 RSN…	/twin
Urban Digital Twin	Strong-motion record	Düzce 1999-11-12 · Düzce (DZC) · N-S 180 · PGA 0.348 g · Mw 7.2	1999-11-12	PEER NGA-West2 RSN…	/twin
Urban Digital Twin	Strong-motion record	Kocaeli 1999-08-17 · Yarımca (YPT) · 060 · PGA 0.268 g · Mw 7.5	1999-08-17	PEER NGA-West2 RSN…	/twin
Urban Digital Twin	Strong-motion record	Kocaeli 1999-08-17 · İzmit (IZT) · 090 · PGA 0.22 g · Mw 7.5	1999-08-17	PEER NGA-West2 RSN…	/twin
Urban Digital Twin	Strong-motion record	Erzincan 1992-03-13 · Erzincan (ERZ) · N-S · PGA 0.515 g · Mw 6.7	1992-03-13	PEER NGA-West2 RSN…	/twin
Urban Digital Twin	Strong-motion record	Kahramanmaraş 2023-02-06 (Pazarcık) · AFAD TK.4614 Pazarcık · E-W · PGA 2.0 g · Mw 7.8	(Pazarcık)	AFAD TADAS 2023 ev…	/twin
Urban Digital Twin	Strong-motion record	Kahramanmaraş 2023-02-06 (Pazarcık) · AFAD TK.3126 Antakya · N-S · PGA 1.23 g · Mw 7.8	(Pazarcık)	AFAD TADAS 2023 ev…	/twin
Sustainable Mining	Province report	Kastamonu · 11 mineral rows · 0xe832ac4a75	2026-10-20	0xe890c11d10d80068…	/mining

Verify paths are relative to https://spaceseax.tech

How to verify

Every row carries a SHA-256 anchor written to the platform ledger when the record was created. Open the verification link, or upload the attached PDF at https://spaceseax.tech/verify/report to compare its hash with the archived copy. KPI values are live counts; the annex content hash is printed in the footer so two copies can be compared.

Every number in this summary is read live from the platform database; the text is deterministic (no LLM) and sealed with a content hash + SHA-256 anchor. Evidence: the anchored ledger, a PDF archive with verification links, council receipt stamps, laboratory and probe calibration records.

Bundle contents

1. TBDY 2018 strength-margin report (digital twin) (3 p.)
2. OpenSees seismic lab report (NLTHA + modal pushover, retrofit what-if) (3 p.)
3. Kastamonu province critical-raw-materials report (3 p.)

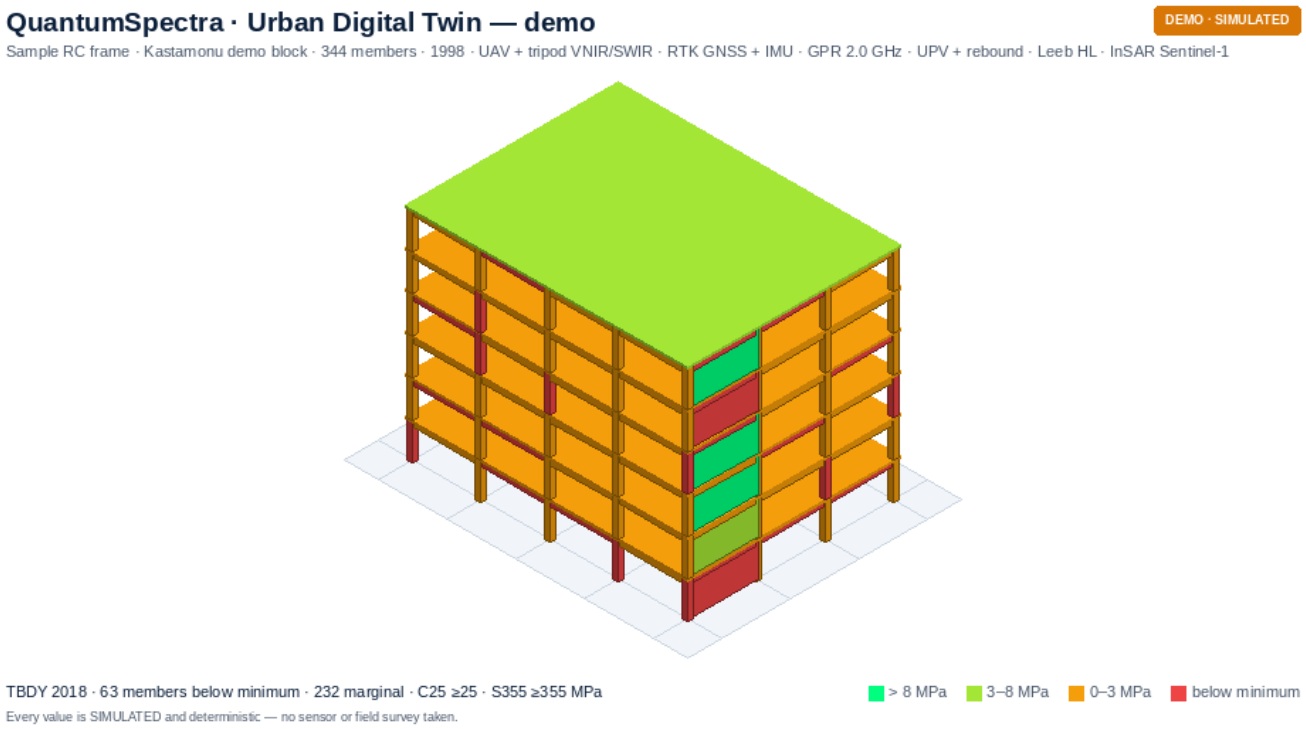
partners@quantumspectra.io · Academic partner: Başkent University · https://spaceseax.tech/pitch

annex content hash eec0b90f64c9d95448e5b6608d502e1c60c3749336a815672d6303ed2e516c39
one-pager anchor 0x3615025815ec826aa588822c532a6508087add5a919dbae53c2084e2b1199a0f · pilot model v1 · 2026-11-25 13:17 UTC

TBDY 2018 Material Margin Report

Sample RC frame · Kastamonu demo block · 344 members · built 1998 · 25 Nov 2026 13:17 UTC · **SIMULATED demo building**

Members below minimum	63 / 344
Marginal (0–3 MPa)	232
Concrete minimum	C25/30 · fck ≥ 25 MPa (TBDY 2018 §7.2.5.1)
Steel minimum	S355 · fy ≥ 355 MPa
Worst margin	-48 MPa (BR3-A)
Measured members (scans)	0



Members below the TBDY 2018 minimum · 63

Member	Kind	Floor	Material	Basis	Value	Min	Margin
BR3-A	brace	2	steel S355	estimate	307 MPa	355	-48 MPa
BR1-B	brace	0	steel S355	estimate	314 MPa	355	-41 MPa
BR2-A	brace	1	steel S355	estimate	318 MPa	355	-37 MPa
BR5-B	brace	4	steel S355	estimate	326 MPa	355	-29 MPa
BY3-01	beam	2	concrete C25/30	estimate	21.6 MPa	25	-3.4 MPa
BY2-01	beam	1	concrete C25/30	estimate	21.7 MPa	25	-3.3 MPa
BX4-30	beam	3	concrete C25/30	estimate	21.9 MPa	25	-3.1 MPa
C4-43	column	3	concrete C25/30	estimate	22 MPa	25	-3 MPa
BY4-42	beam	3	concrete C25/30	estimate	22 MPa	25	-3 MPa
C4-13	column	3	concrete C25/30	estimate	22.1 MPa	25	-2.9 MPa
BY6-42	beam	5	concrete C25/30	estimate	22.1 MPa	25	-2.9 MPa
BY1-42	beam	0	concrete C25/30	estimate	22.2 MPa	25	-2.8 MPa

BY2-30	beam	1	concrete C25/30	estimate	22.2 MPa	25	-2.8 MPa
C1-20	column	0	concrete C25/30	estimate	22.3 MPa	25	-2.7 MPa
P-41	pile	-1	concrete C25/30	estimate	22.3 MPa	25	-2.7 MPa
C3-02	column	2	concrete C25/30	estimate	22.4 MPa	25	-2.6 MPa
P-10	pile	-1	concrete C25/30	estimate	22.4 MPa	25	-2.6 MPa
BY3-41	beam	2	concrete C25/30	estimate	22.5 MPa	25	-2.5 MPa
BY6-02	beam	5	concrete C25/30	estimate	22.5 MPa	25	-2.5 MPa
C3-40	column	2	concrete C25/30	estimate	22.7 MPa	25	-2.3 MPa
C5-10	column	4	concrete C25/30	estimate	22.7 MPa	25	-2.3 MPa
C2-00	column	1	concrete C25/30	estimate	23 MPa	25	-2 MPa
BY4-01	beam	3	concrete C25/30	estimate	23.1 MPa	25	-1.9 MPa
C2-30	column	1	concrete C25/30	estimate	23.2 MPa	25	-1.8 MPa
BX5-02	beam	4	concrete C25/30	estimate	23.2 MPa	25	-1.8 MPa
BY6-41	beam	5	concrete C25/30	estimate	23.2 MPa	25	-1.8 MPa
BY5-32	beam	4	concrete C25/30	estimate	23.3 MPa	25	-1.7 MPa
C1-03	column	0	concrete C25/30	estimate	23.4 MPa	25	-1.6 MPa
BY1-00	beam	0	concrete C25/30	estimate	23.4 MPa	25	-1.6 MPa
BX3-22	beam	2	concrete C25/30	estimate	23.4 MPa	25	-1.6 MPa
C5-30	column	4	concrete C25/30	estimate	23.5 MPa	25	-1.5 MPa
C1-33	column	0	concrete C25/30	estimate	23.8 MPa	25	-1.2 MPa
C3-31	column	2	concrete C25/30	estimate	23.9 MPa	25	-1.1 MPa
C5-13	column	4	concrete C25/30	estimate	23.9 MPa	25	-1.1 MPa
BX1-23	beam	0	concrete C25/30	estimate	24 MPa	25	-1 MPa
BY1-41	beam	0	concrete C25/30	estimate	24 MPa	25	-1 MPa
BY3-30	beam	2	concrete C25/30	estimate	24 MPa	25	-1 MPa
BY4-20	beam	3	concrete C25/30	estimate	24 MPa	25	-1 MPa
C1-43	column	0	concrete C25/30	estimate	24.1 MPa	25	-0.9 MPa
BY6-01	beam	5	concrete C25/30	estimate	24.1 MPa	25	-0.9 MPa
BY1-01	beam	0	concrete C25/30	estimate	24.2 MPa	25	-0.8 MPa
BX2-13	beam	1	concrete C25/30	estimate	24.2 MPa	25	-0.8 MPa
C2-41	column	1	concrete C25/30	estimate	24.3 MPa	25	-0.7 MPa
C3-01	column	2	concrete C25/30	estimate	24.3 MPa	25	-0.7 MPa
BY1-40	beam	0	concrete C25/30	estimate	24.4 MPa	25	-0.6 MPa
BX2-30	beam	1	concrete C25/30	estimate	24.4 MPa	25	-0.6 MPa
BX1-13	beam	0	concrete C25/30	estimate	24.5 MPa	25	-0.5 MPa
BX4-20	beam	3	concrete C25/30	estimate	24.5 MPa	25	-0.5 MPa
BX6-13	beam	5	concrete C25/30	estimate	24.5 MPa	25	-0.5 MPa
BX2-20	beam	1	concrete C25/30	estimate	24.6 MPa	25	-0.4 MPa
C4-23	column	3	concrete C25/30	estimate	24.6 MPa	25	-0.4 MPa

C5-11	column	4	concrete C25/30	estimate	24.6 MPa	25	-0.4 MPa
BY5-00	beam	4	concrete C25/30	estimate	24.6 MPa	25	-0.4 MPa
BX1-30	beam	0	concrete C25/30	estimate	24.7 MPa	25	-0.3 MPa
C2-02	column	1	concrete C25/30	estimate	24.7 MPa	25	-0.3 MPa
BX2-03	beam	1	concrete C25/30	estimate	24.7 MPa	25	-0.3 MPa
BY4-40	beam	3	concrete C25/30	estimate	24.7 MPa	25	-0.3 MPa
P-40	pile	-1	concrete C25/30	estimate	24.7 MPa	25	-0.3 MPa
C2-11	column	1	concrete C25/30	estimate	24.8 MPa	25	-0.2 MPa
C3-00	column	2	concrete C25/30	estimate	24.8 MPa	25	-0.2 MPa
BY5-42	beam	4	concrete C25/30	estimate	24.8 MPa	25	-0.2 MPa
BX1-20	beam	0	concrete C25/30	estimate	24.9 MPa	25	-0.1 MPa
BX4-03	beam	3	concrete C25/30	estimate	24.9 MPa	25	-0.1 MPa

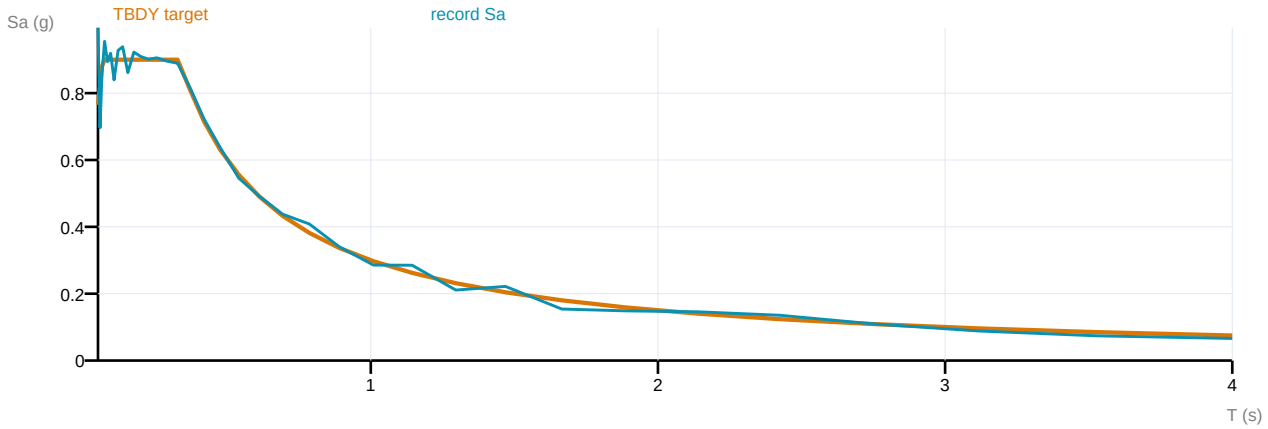
Strengths are SonReb / Leeb-calibrated quantum-hyperspectral estimates; measured rows use uploaded scan health. Verify with cores before regulatory use.
SHA-256 anchor: a6ec3827dc995223086e600130dd9e2755017d73bc514377bc990ec93d13a754

Seismic Analysis Lab — council report

Sample RC frame · Kastamonu demo block · 6 storeys · 2026-11-25 13:17 UTC · SIMULATED demo building — lumped-mass shear model from surveyed member strengths

Hazard	TBDY 2018 DD-2 (475-yr) · S_S 0.75 · S_1 0.2 · ZC · S_DS 0.9 · S_D1 0.3 · T_A 0.0667 s · T_B
Record	Synthetic · matched to TBDY 2018 DD-2 (475-yr) · ZC · seed 7 · PGA 0.3812 g · PGV 48.3 cm/s
Modes	T1 0.723 s (87.1 %) · T2 0.246 s (8.8 %) · T3 0.154 s (2.6 %) · Rayleigh αM 0.64848 βK 0.00292
Run anchor	0x3b3fca432ffbf62f3429e4302558ebccec25041106b752cc40a6b51cb4ba9d69

1 · Target spectrum vs record

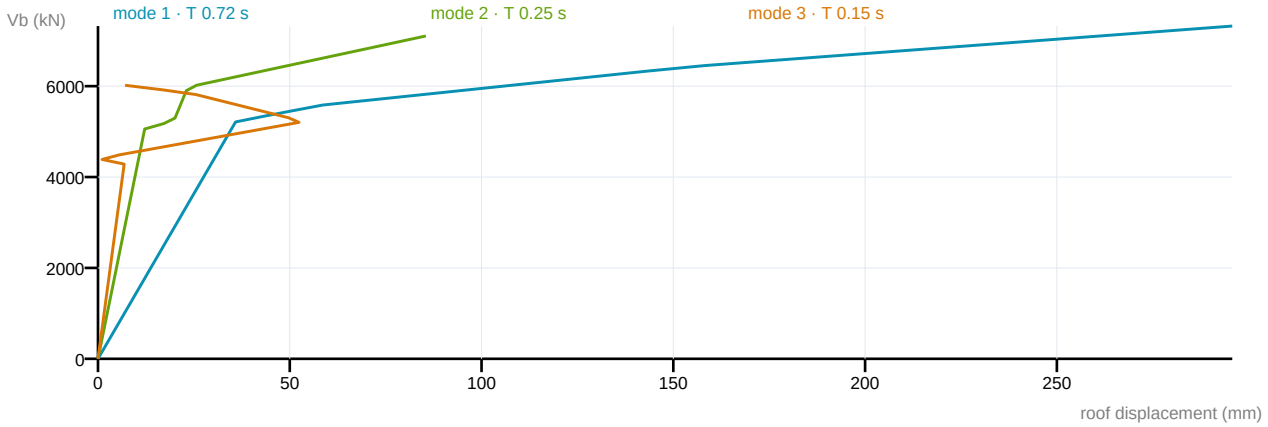


2 · Storey drifts — NLTHA vs Modal Pushover

Storey	NLTHA %	residual %	MPA SRSS %	MPA CQC %	TBDY level
S6	0.15	0.00	0.10	0.10	SH
S5	0.26	0.01	0.18	0.18	SH
S4	0.30	0.02	0.22	0.22	SH
S3	0.45	0.14	0.25	0.25	SH
S2	0.30	0.03	0.42	0.42	SH
S1	1.04	0.14	1.08	1.08	KH

NLTHA verdict: **KH** · max drift 1.04 % @ S1 · ASCE 41-23 LS · EC8-3 SD · V_b,max 5,651 kN (C_s 0.207) · u_roof 79.7 mm · 0 dt-halvings

3 · Modal capacity curves (Chopra–Goel MPA)



Mode	T (s)	M* %	Sa_y (g)	Sd_y (mm)	R_y	C_R	roof target (mm)	regime

1	0.723	87.1	0.233	30.13	1.781	1.0	67.9	inelastic
2	0.246	8.8	2.333	35.07	0.386	1.0	5.2	elastic
3	0.154	2.6	3.1242	18.1	0.288	1.0	1.0	elastic

4 · Retrofit what-if (same record, same hazard)

Scheme	T1 (s)	max drift %	Δ %	NLTHA	MPA	V_b (kN)	capex (M TRY)	months
As surveyed (baseline)	0.723	1.04	—	KH	KH	5,651	—	—
CFRP wrapping of columns/joints	0.706	0.80	-23	KH	KH	6,550	10.9	3
RC column/beam jacketing	0.622	0.62	-41	SH	KH	8,318	16.8	7
Steel concentric bracing	0.525	0.47	-55	SH	SH	9,110	15.3	5

TBDY 2018 existing-building target under DD-2: Controlled Damage (KH) or better

5 · Feasibility — strengthening vs demolition & reconstruction

Option	total (M TRY)	months	level	meets KH	EAL after (k TRY/y)	NPV 30y (M TRY)	payback (y)	BCR
CFRP wrapping of columns/joints	11.1	3	KH	yes	498	-11.5	—	-0.03
RC column/beam jacketing	18.5	7	SH	yes	124	-15.2	63.9	0.18
Steel concentric bracing	16.1	5	SH	yes	124	-13.2	64.1	0.18
Demolition & reconstruction (TBDY 2018 new build)	78.1	24	SH	yes	124	-73.0	—	0.02

Verdict: As surveyed the block already reaches KH under DD-2 — strengthening is optional; the cheapest scheme that materially lowers drift is CFRP wrapping of columns/joints (11.1 M TRY, 14 % of demolition & reconstruction).

Reconstruction breakdown: construction 67.2 · demolition 2.3 · temporary housing 3.2 · soft costs 5.4 M TRY · assumptions: 2592.0 m² · 24 flats · RCN 24,000.0 TRY/m² · discount 8 % · 30 y · EAL by level {'SH': 0.002, 'KH': 0.008, 'GÖ': 0.025, 'COLLAPSE': 0.06}

OpenSees cannot run on the platform server (aarch64); the exported OpenSeesPy scripts reproduce this model and record so the results can be independently re-run. Costs are 2026 planning estimates, not quotations.

Kastamonu Province — Mineral Inventory Report

For the Governorate of Kastamonu · hyperspectral research programme · generated 2026-10-20 08:42 UTC · report anchor 0xe890c11d10d80068…

Province summary

Indicative occurrences	11 mineral occurrences · 5 strategic / EU-CRM relevant
Platform research sites	3 sites · 3 surveyed · 0 engineered · 0 with drill plans
Kriged resource (engineered sites)	no engineered sites yet
High / critical tailings	none
Adopted into zoning	none yet

Indicative mineral table

Mineral	District	Deposit type · status	Indicative grade · size	SWIR diagnostic	High-tech use	Criticality
Copper (massive sulphide, Cyprus-type) Cu, Co, Au, Ag	Küre (Aşıköy, Bakibaba)	VMS in ophiolitic basalts active underground mine	1.5–2.5 % Cu · Co 0.1 % · Au 0.3 g/t ≈ 30–40 Mt historic + resource	chlorite 2330 nm · sericite 2200 nm · jarosite 2265 nm (oxidised gossan) high (gossan / alteration halo)	Cu wiring, Co batteries (by-product)	strategic
Copper–gold (porphyry / epithermal prospect) Cu, Au, Mo	Hanönü, Taşköprü north	porphyry-related veins exploration	0.3–0.8 % Cu · 0.2–0.6 g/t Au unquantified	kaolinite 2165 nm · alunite 2170 nm · sericite 2200 nm high (argillic alteration)	Cu, Au electronics	strategic
Manganese Mn	Daday, Tosya, Küre	sedimentary / volcanogenic Mn oxides small-scale historic	25–40 % Mn small lenses (0.1–1 Mt)	Mn-oxide broad VNIR absorption 400–1100 nm · low SWIR albedo moderate	LMO / NMC cathodes, steel	strategic (EU CRM)
Chromite Cr	Cide, Araç ophiolite	podiform chromite in serpentinised peridotite historic / exploration	30–45 % Cr_2O_3 pods < 0.5 Mt	serpentine 2320 nm · chromite Fe^{2}□ 590 nm moderate (host serpentinite)	stainless & superalloys	important
Iron (skarn / magnetite) Fe	Taşköprü, Tosya	contact skarn historic	45–60 % Fe 1–5 Mt	goethite / hematite 860–920 nm · garnet 1250 nm high	—	commodity
Hard coal / lignite C	Azdavay, Söğütözü, Pınarbaşı	Carboniferous coal measures active small mines	5 500–7 000 kcal/kg (hard coal) tens of Mt	organic carbon low albedo · 1700 nm C–H high (spoil heaps, AMD gossan)	—	commodity (phase-down)
Marble / limestone (dimension stone) $CaCO_3$	Tosya, Taşköprü, Devrekani	recrystallised platform carbonates active quarries	70–95 % recoverable block large	calcite 2340 nm · dolomite 2320 nm very high	—	commodity

Quartzite / silica SiO_2	Tosya, Taşköprü	metamorphic quartzite active quarries	> 97 % SiO_2 large	spectrally flat · 1400/1900 nm water-free high (bright, featureless)	ferro-silicon, glass, polysilicon feedstock (CRM: silicon metal)	strategic (silicon metal)
Bentonite / clays smectite	Taşköprü, Daday	altered tuff historic / small	montmorillonite 60–80 % 0.5–2 Mt	smectite 2210 nm · 1900 nm water very high	drilling fluids, Li-clay analogue host	important
Dolomite / magnesite Mg	Araç, Cide ophiolite margins	cryptocrystalline magnesite veins exploration	40–46 % MgO small	magnesite 2300 nm · dolomite 2320 nm high	Mg metal, refractories (EU CRM: magnesium)	strategic
Gold (placer / vein — indicative) Au	Küre gossan zone, Devrekani streams	oxidised VMS cap + alluvial exploration target	0.3–1.5 g/t Au unquantified	jarosite 2265 nm · goethite 900 nm (gossan proxy; Au itself spectrally silent) indirect (pathfinder minerals)	electronics, reserve asset	—

Order-of-magnitude figures from public geological knowledge — not reserves. Rows map to platform commodities via the one-tap site builder (district centroid coordinates pre-filled).

Platform research sites

Site	Commodity · status	Survey	Tailings	Resource (kriged)	NPV base M$	Verdict
Küre Massive-Sulphide Cu-Au 41.1466, 33.4802	gold active · 7.0 km²	v1 · 2.78 g/t Au	MODERATE · 35.6 → Karaçomak Dam / Gökırmak 33.6 km	not engineered	—	grade B · buffer 3.9 km VIOLATED
Hanönü Copper-Gold Prospect 41.0501, 33.4141	copper exploration · 5.0 km²	v1 · 0.77 % Cu	LOW · 17.3 → Karaçomak Dam / Gökırmak 44.8 km	not engineered	—	grade A · buffer 2.8 km OK
Taşköprü Industrial Minerals (quartzite / marble) 41.3054, 34.1283	quarry active · 4.0 km²	v1 · 77.8 % usable aggregate	LOW · 10.6 → Karaçomak Dam / Gökırmak 27.5 km	not engineered	—	grade A · buffer 2.9 km OK

Metal price basis

Commodity	Price	Unit	Basis	vs reference
chromite	290.0	$/t Cr_2O_3 conc.	REFERENCE TABLE — add METALS_API_KEY (metals.dev) for live quotes	—
copper	11,896.13	$/t Cu	LIVE · Yahoo Finance HG=F (keyless, delayed)	+23.9 %
gold	113.25	$/g Au	LIVE · Yahoo Finance GC=F (keyless, delayed)	+66.5 %

iron	105.0	$/t 62 % Fe fines	REFERENCE TABLE — add METALS_API_KEY (metals.dev) for live quotes	—
lignite	38.0	$/t	REFERENCE TABLE — add METALS_API_KEY (metals.dev) for live quotes	—
magnesite	340.0	$/t dead-burned magnesite	REFERENCE TABLE — add METALS_API_KEY (metals.dev) for live quotes	—
manganese	4.9	$/dmtu Mn (≈ 490 $/t contained Mn, 44 % ore ≈ 215 $/t)	REFERENCE TABLE — add METALS_API_KEY (metals.dev) for live quotes	—
marble	420.0	$/m³ block	REFERENCE TABLE — add METALS_API_KEY (metals.dev) for live quotes	—
quarry	14.0	$/t aggregate	REFERENCE TABLE — add METALS_API_KEY (metals.dev) for live quotes	—

Detection plan

1. Sentinel-2 / EnMAP SWIR regional screening for gossan (jarosite 2265 nm) and argillic alteration (2165–2200 nm)
2. UAV hyperspectral terrain scan of Küre–Hanönü alteration halos (5 cm GSD)
3. downhole hyperspectral probe logging of exploration boreholes for Cu-Co sulphide and Mn-oxide indices
4. open-pit & quarry monitoring of carbonate / silica purity (2340 nm calcite depth) for industrial-mineral grading

Provenance

Report anchor	`0xe890c11d10d800681ff8f6748921cc8c29908e5e3a8cc4f6527910eaa1ae1a51`
Küre Massive-Sulphide Cu-Au · site	`0xa7ff27ea4e688b73128e4b36290b3e76dfad7dad66a2b65ebbbbe09aedea534a`
Hanönü Copper-Gold Prospect · site	`0x332f2b60b0a79ab8d06ba51dc48e7093e62df11e0e0bed9042a1233bc739f84a`
Taşköprü Industrial Minerals · site	`0x123ba5e22da15dc7120bfb42070d044f547c788ae807c348cb798717126f5612`

SHA-256 anchors (SIMULATED chain). Spectral indices simulated; satellite land-use live when a scene is available. Research-grade — verify with field sampling before regulatory or investment decisions.