References
2017 - ongoing

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Tunnel Projects	Period	Tunnelling Technology	System	Geology	Prediction Targets
MUSAIMEER PUMPING STATION AND OUTFALL PROJECT, **Qatar**	start 2019	1 EPB-TBM, ∅ 3.7 m, CREG	INTEGRAL	limestones, shales, chalky groundwater	Karst and water-bearing cavities, fault zones, water salinity, zones of increased porosity
DUBAI DEEP STORMWATER TUNNEL, **United Arab Emirates (UAE)**	start 2019	2 EPB-TBM, ∅ 11.08 m, CREG	INTEGRAL	sandstones, mudstones	air and water-bearing fault and fracture zones, with potentially increased permeability, cavities, clayey softground zones
BRENNER BASE TUNNEL, LOT MULES 2-3 **Italy**	2018 - ongoing	1-3 DS-TBM, ∅ 6.85 m -10.71 m, HERRENKNECHT	INTEGRAL	granite, gneisses, schistes	fault zones, nappe structures, potential water-bearing zones
METRO ROMA GALLERIA TRATTA T3 **Italy**	2018 - ongoing	2 EPB-TBM, ∅ 6.7 m, HERRENKNECHT	INTEGRAL	silt, clay, sand, gravel	cavities
Galleria Santa Lucia Lotto 2, **Italy**	2017 - ongoing	1 EPB-TBM, ∅ 15.87m, HERRENKNECHT	INTEGRAL	Carbonate sequences	Karst zones, Karst cavities, and fault zones
Galerie Des Janots **France**	2017 - ongoing	1 Gripper TBM, ∅ 3.50 m, HERRENKNECHT	INTEGRAL	Limestones and Dolomites	Karst cavities

References
2015 - 2017

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Tunnel Projects	Period	Tunnelling Technology	System	Geology	Prediction Targets
METRO TEHRAN LINE 6 **Iran**	2017	1 EPB-TBM, ∅ 9.15 m, HERRENKNECHT	INTEGRAL	Sand, gravel, clay	Construction objects like shafts and steel structures
5th Water Supply System to Jerusalem **Israel**	2016 - 2017	1 Hard Rock TBM, ∅ 3.90 m, ZUEBLIN	INTEGRAL	Limestones	Karst zones, Karst cavities, and fault zones
IDRIS MTS-01, Sewerage Tunnel **Qatar**	2017 - 2018	2 EPB-TBMs, ∅ 3.85 m, HERRENKNECHT	INTEGRAL	limestones, shales, chalky limestones, Evaporites, Karst, silty clayey material	Karst and water-bearing cavities, fault zones, water salinity, zones of increased porosity
METRO ATHENS LINE 3 EXTENSION **Greece**	2016 - 2017	EPB TBM, ∅ 9.5m, LOVAT	INTEGRAL	siltstones, serpentinites, limestones	Karst zones including large cavities
Uma Oya Multipurpose Development Project, **Sri Lanka**	2016	1 Double Shield TBM, ∅ 4.3m, HERRENKNECHT	INTEGRAL	gneisses	Fault zones, potential water-inflow and gas-inflow zones, characterization of relative fracturing
SS1 Nuova Aurelia Highway Tunnel, **Italy**	2015 - 2018	Single Shield TBM, ∅ 13.72m, HERRENKNECHT	INTEGRAL	gneisses, amphibolites	Fault zones, fracture zones, water-bearing zones

References
2014 - 2015

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Tunnel Projects	Period	Tunnelling Technology	System	Geology	Prediction Targets
METRO PARIS LINE 14 LOT T01, France	2015 - 2018	2 EPB-TBMs, ∅ 8.9 m, HERRENKNECHT	INTEGRAL	marlstones, limestones, gypsum, sand, gravel	Karst zones, Karst cavities, and fault zones
METRO PARIS LINE 14 LOT T02, France	2015 - 2018	1 EPB-TBMs, ∅ 8.96 m, NFM TECHNOLOGIES	INTEGRAL	marlstones, limestones, gypsum, sand, gravel	Karst zones, Karst cavities, and fault zones
METRO RIYADH LINE 5, Saudi Arabia	2015-2016	2 EPB-TBMs, ∅ 9.73 m, HERRENKNECHT	SCAN	limestone formation of grades partly brecciated	Karst zones, air-filled/water-bearing cavities, fault zones, zones of increased porosity
METRO RIYADH LINE 3, Saudi Arabia	2015 - 2017	1 EPB-TBM, ∅ 10.16 m, NFM TECHNOLOGIES	INTEGRAL	limestone formation of grades partly brecciated	Karst zones, air-filled/water-bearing cavities, fault zones, zones of increased porosity
AZAD WATER CONVEYANCE TUNNEL, Iran	2015 - 2018	1 EPB-TBM, ∅ 3.71 m, HERRENKNECHT	INTEGRAL	conglomerates, sandstones and mudstones, limestones, shales	Fault and fracture zones
METRO DOHA Gold Line, Qatar	2014-2016	6 EPB-TBMs, ∅ 7.05 m, HERRENKNECHT	SCAN	limestones, shales, chalky limestones, Evaporites, Karst, silty clayey material	Karst and water-bearing cavities, fault zones, zones of increased porosity

References
2012 - 2014

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Tunnel Projects	Period	Tunnelling Technology	System	Geology	Prediction Targets
METRO DOHA Red Line North, Qatar	2014-2016	4 EPB-TBMs, ∅ 7.05 m, HERRENKNECHT	INTEGRAL/ SCAN	limestones, shales, chalky limestones, Evaporites, Karst, silty clayey material	Karst and water-bearing cavities, fault zones, zones of increased porosity
METRO DOHA Green Line, Qatar	2014-2016	6 EPB-TBMs, ∅ 7.05 m, HERRENKNECHT	SCAN	limestones, shales, chalky limestones, Evaporites, Karst, silty clayey material	Karst and water-bearing cavities, fault zones, zones of increased porosity
HEADRACE TUNNEL PROJECTS PANDO, Panama	2014-2015	EPB-TBMs, ∅ 3.78 m, LOVAT	INTEGRAL	lahars formation, pyroclastis	differentiation between clay and debris, fault zones and water-bearing zones
ABU HAMOUR DRAINAGE TUNNEL, Qatar	2014-2015	2 EPB-TBMs, ∅ 4.52 m, HERRENKNECHT	INTEGRAL	limestones, shales, chalky limestones, Evaporites, Karst, silty clayey material	Karst and water-bearing cavities, fault zones, zones of increased permeability
STEP DEEP TUNNEL SEWER - T03, United Arab Emirates (UAE)	2012	2 EPB-TBMs, ∅ 6.34 m, HERRENKNECHT	INTEGRAL	dolomitic claystones and siltstones, gypsum, clay, silt	water-bearing cavities, zones of increased permeability
GALLERIA MACUGNAGA, Highway Pilottunnel, Alps, Italy	2012	Hard Rock GripperTBM, ∅ 3.60 m	INTEGRAL	mica schists	fault zones, weathered mica schists

References
2008 - 2011

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Tunnel Projects	Period	Tunnelling Technology	System	Geology	Prediction Targets
GALLERIA SPARVO, **Highway Bologna-Florence, Italy**	2011-2012	EPB-TBM, ∅ 15.55 m, HERRENKNECHT	SCAN	unconsolidated weathered complex ophiolitic geology	fault zones, differentiation between arenitic and argilitic/pelitic lithology
STEP DEEP TUNNEL SEWER - T02, **United Arab Emirates (UAE)**	2011-2012	3 EPB-TBMs, ∅ 6.34 m, HERRENKNECHT	SCAN	dolomitic claystones and siltstones, gypsum, clay, silt	water-bearing cavities, zones of increased permeability
METRO ROMA LINEA C, T4 **Italy**	2010-2011	2 EPB-TBMs, ∅ 6.7 m, HERRENKNECHT	SCAN	gravel, clay, silt, silty clay, pyroclastics	cavities and archeological remains ahead and around of face
GASTAU Gaspipe Project, **Brazil**	2009-2011	DS-GRIPPER TBM, ∅ 6.3 m, WIRTH	INTEGRAL	gneisses, granites, diabas dykes	subhorizontal and subvertical water-bearing fault and fracture zones
TARRASA UTE Railway Project, **Spain**	2009	EPB-TBM, ∅ 6.4 m, LOVAT	INTEGRAL	clay/silt, silty gravel sand/gravel, clayey carbonates, karst structures	(reinforced) concrete structures of old fundations and water wells linings, structures of Karst and old piles
Brenner Base Tunnel, **Austria - Italy**	2008-2010	DS-TBM, ∅ 6.3 m, WIRTH	INTEGRAL	granites, gneisses	fault zones

References
2007 - 2009

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Tunnel Projects	Period	Tunnelling Technology	System	Geology	Prediction Targets
METRO ROMA LINEA C, T5, Italy	2009-2010	2 EPB-TBMs, ∅ 6.7 m, HERRENKNECHT	SCAN	gravel, clay, silt, silty clay, pyroclastics	cavities and archeological remains ahead and around of face
METRO ROMA LINEA C, T6A, Italy	2008-2009	2 EPB-TBMs, ∅ 6.7 m, HERRENKNECHT	SCAN	gravel, clay, silt, silty clay, pyroclastics	cavities and archeological remains ahead and around of face
Blessberg Tunnel, Germany (Erfurt - Nuremberg)	2008	Perimeter exploration in an existing tunnel	PERIMETER	limestones	karst cavities, open air-filled and filled with sand, gravel
METRO NAPOLI LINEA 1, Italy	2008	S-TBM, ∅ 6.7 m, HERRENKNECHT	INTEGRAL	tuff	old-mine cavities
TÚNEL DE LA CABRERA, Spain (Valencia-Madrid)	2007-2008	DS-TBM, ∅ 9.5 m, HERRENKNECHT	SCAN, INTEGRAL	limestones and dolomites	water-bearing fault/ karst zones and cavities
METRO NAPOLI LINEA 1, Italy	2007	S-TBM, ∅ 6.7 m, HERRENKNECHT	INTEGRAL	tuff	old-mine cavities

References
2006 - 2007

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Tunnel Projects	Period	Tunnelling Technology	System	Geology	Prediction Targets
VAL PASSIRIA Project, Italy	2007-2008	DS-TBM, ∅ 3.7 m, WIRTH	INTEGRAL	gneisses	water-bearing fault zones
Proyecto del Emisario Submarino de Berria, Spain	2006-2007	Micro-TBM AVN2000D, ∅ 2.0 m, HERRENKNECHT	INTEGRAL	limestones	karst cavities
BELES Multipurpose Project, Ethiopia	2006-2008	DSU-EPB-TBM, ∅ 8.1 m, SELI	INTEGRAL	volcanic rock, pyroclastics, various kind of basalt, lacustrine sediments	water-bearing fault zones, disintegrated weathering zones, silty areas
CANADA LINE, Canada (Vancouver - Int. Airport Vancouver)	2006-2007	EPB-TBM, ∅ 6.1 m, LOVAT	INTEGRAL	sandstone, till, clayey sandy silt, coarse sand, siltstone	transition zones between sandstone and till, water-bearing formations
Water Supply Tunnel TBM 1 + 3, China	2006	Gripper TBM, ∅ 8.3 m, ROBBINS	INTEGRAL	volcanics, metamorphics, marbles	karst cavities and fault zones with potential water-inrush zones
PAJARES Tunnels Lot 1, Spain (León-Asturias)	2006	2 DS-TBM, ∅ 9.9 m, HERRENKNECHT and NFM	INTEGRAL	folded and faulted schistes, grey wakes and karstic limestones	water-bearing fault/ karst zones and cavities

References
2004 - 2006

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Tunnel Projects	Period	Tunnelling Technology	System	Geology	Prediction Targets
Headrace Tunnel, China	2006	Boring jumbo Drill + Blast	D+B-SCAN	volcanics, metamorphics, marbles	karst cavities and fault zones with potential water-inrush zones
Jin Ping II Hydropower Project, China	2006	Boring jumbo Drill + Blast	D+B-SCAN	marbles, schistes	water- and air-/gas-filled caverns
ABDALAJIS Tunnel West, Spain (Malaga-Cordoba)	2004-2005	Double-shield TBM, ∅ 10.2 m, MITSUBISHI/ ROBBINS	INTEGRAL	clay-/siltstones, limestones, marls, dolomites	weak claystones, karst structures, water- and gas-filled cavities and fault zones
Metro Barcelona Linea 9, Spain	2004-2005	Dual Rock-Soil TBM, ∅ 11.95 m, WIRTH/ NFM	INTEGRAL	granite, discomposed granite (sand, gravel and boulders)	fault and fracture zones, (thermal) water-bearing zones
PRISNIG Tunnel, Italy	2004-2005	Open type TBM, ∅ 5.80 m, JARVA	INTEGRAL	calcareous and anhydrite/ gypsum formations	fault/ karst zones and caverns
Guadarrama North-Tunnel, Spain (Madrid-Segovia)	2004	Double-shield TBM, ∅ 9.51 m, HERRENKNECHT	INTEGRAL	gneisses and intrusive rocks of granitoid type	finegrained (mylonitic) shear zones

References
2000 - 2003

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Tunnel Projects	Period	Tunnelling Technology	System	Geology	Prediction Targets
GOTTHARD Base Tunnel, South Portal, Switzerland	2003-2004	2 Gripper TBMs, ∅ 9.51 m, HERRENKNECHT	INTEGRAL	gneisses	subhorizontal and subvertical water-bearing fault and fracture zones
GOTTHARD Base Tunnel, Section Sedrun, Switzerland	2003	Drill & Blast	D+B-SCAN	schists and gneisses	water-bearing fault zones
Stammham Tunnel, Germany (Nuremberg – Ingolstadt)	2002-2003	Perimeter exploration in existing tunnel	PERIMETER	limestones and dolomite	karst cavities, open air-filled and filled with sand, gravel
Geisberg Tunnel, Germany (Nuremberg – Ingolstadt)	2002-2003	Perimeter exploration in existing tunnel	PERIMETER	limestones and dolomite	karst cavities, open air-filled and filled with sand, gravel
GINORI Tunnel, Italy (Florence-Bologna)	2000-2003	Telescopic-shield TBM, ∅ 6.3 m, WIRTH	SCAN	limestones	high water-bearing and high permeability subvertical karst and fault zones
Irlahuell Tunnel, Germany (Nuremberg – Ingolstadt)	2000-2003	Perimeter exploration in existing tunnel	PERIMETER	limestones and dolomite	karst cavities, open air-filled and filled with sand, gravel
Loetschberg Base Tunnel, Switzerland	2000	Drill & Blast Boring jumbo	D+B-SCAN	schists, marls and limestone	karst-structures and clayey schist shear zones