Knickpoint evolution across anticline structure: A case of uplifted reach in the Taan River, Taiwan

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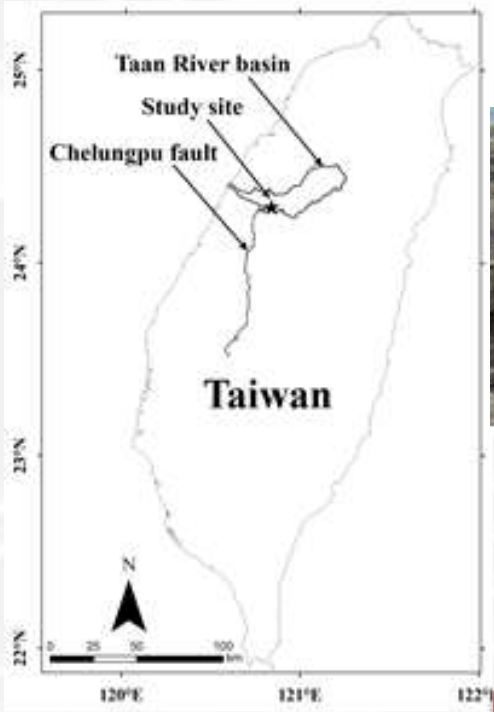
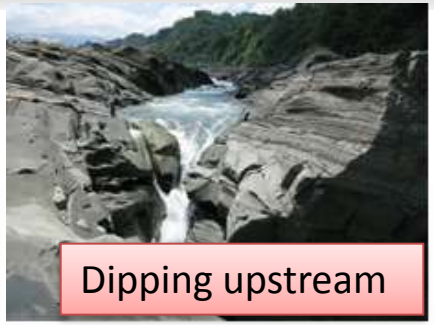
Outline

- Introduction
- Study site
- Study methods
- Discussion
- Conclusion

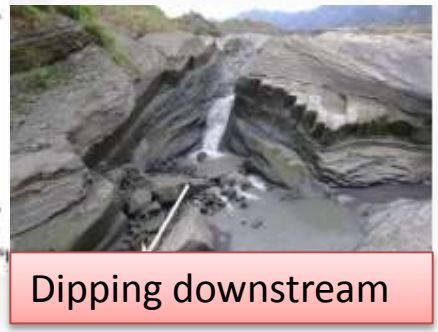
Introduction

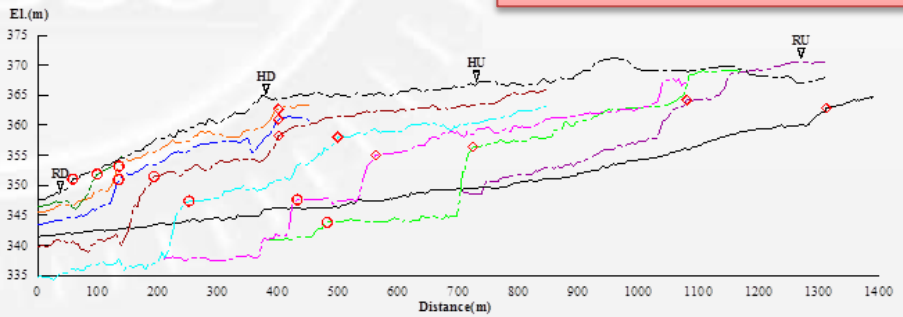
- Knickpoint
  - a localized discontinuity zone with steep slope
  - Intensified erosive power
  - Migration rate mm~cm/year
- Typically formed when
  - abrupt base-level fall
    - Climate change
    - Sea-level fall
    - Earthquake rupture
  - Bedrock resistance changes
- The uplift reach in theTaan River
  - 10m uplifted after the 1999 Chi-Chi EQ.
  - Rapid migration rate in tens ~ hundreds meters annually
  - Three distinct types of knickpoint evolution models



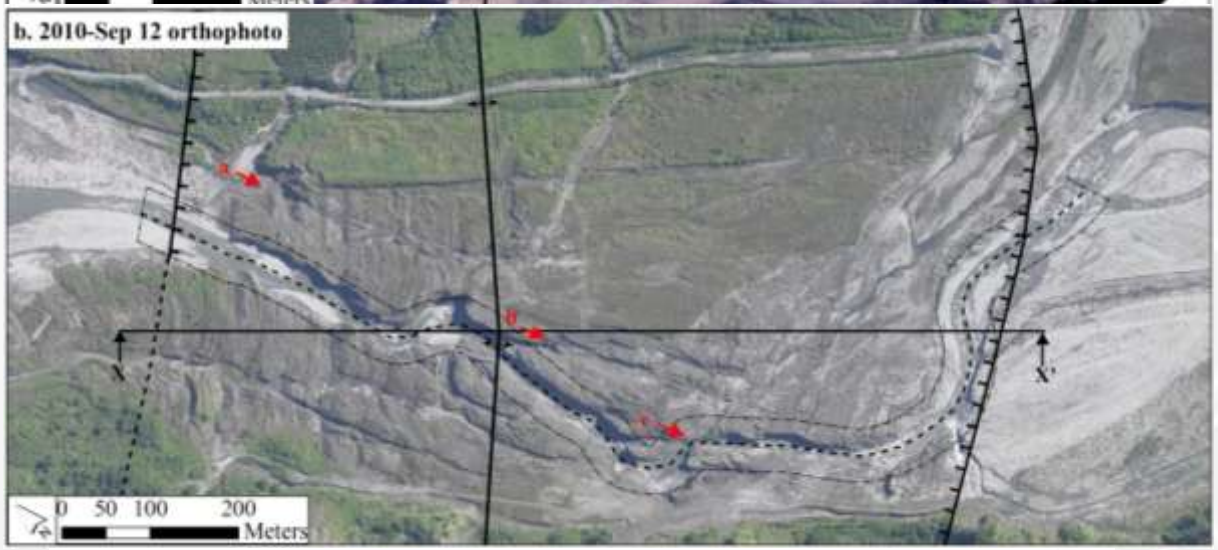

Dipping upstream

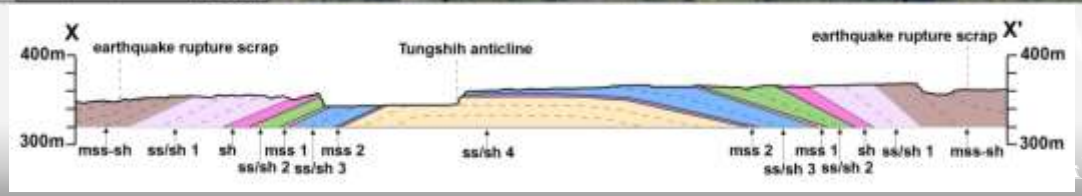

horizontal rocks

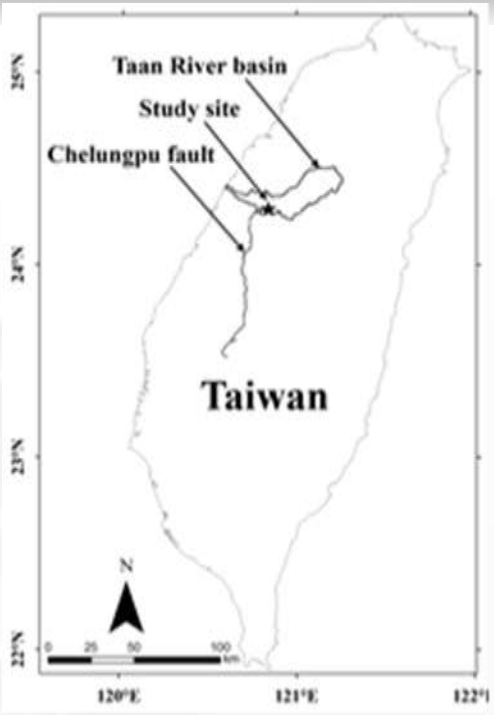

Dipping downstream



Study site



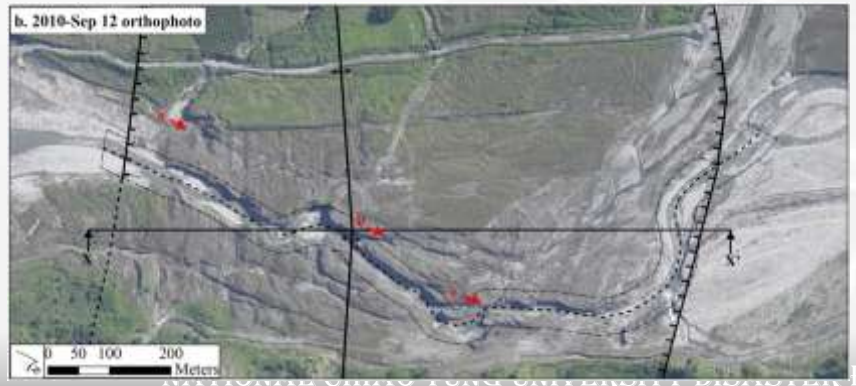




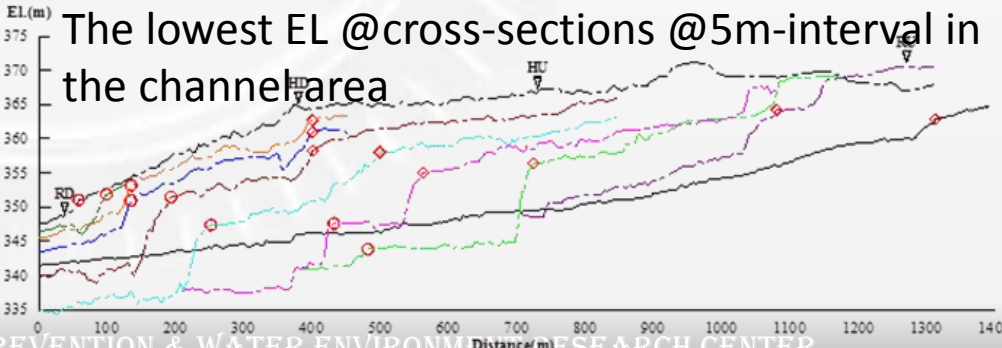
- The Taan River
  - Drains 758 km^2
  - Trunk length 96 km
  - Headwater in EL. 3500m
- The uplift reach
  - Two ruptures parallel to the Tungshih anticline
  - Max. 10m uplifted
  - 1 km longitudinal length
  - Pliocene weak sed. rock

Study method

- Periodical field investigation since 2008
  - Surface geology
  - Erosion conditions
  - Landform changes
- Analyses of longitudinal profile
  - Twelve multi-staged DEM derived from aerial photographs
  - Airborne LiDAR (light detection and ranging)



The lowest EL @cross-sections @5m-interval in the channel area



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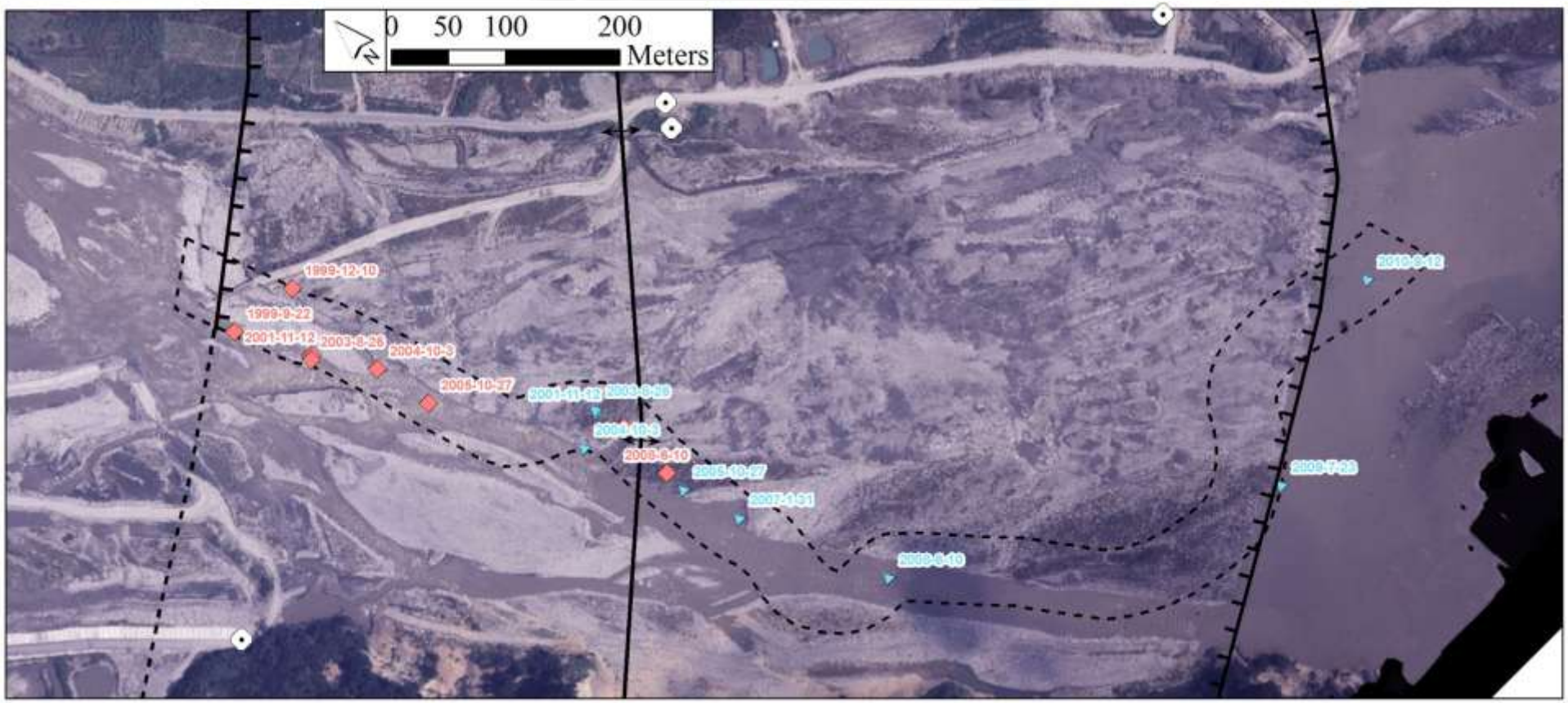
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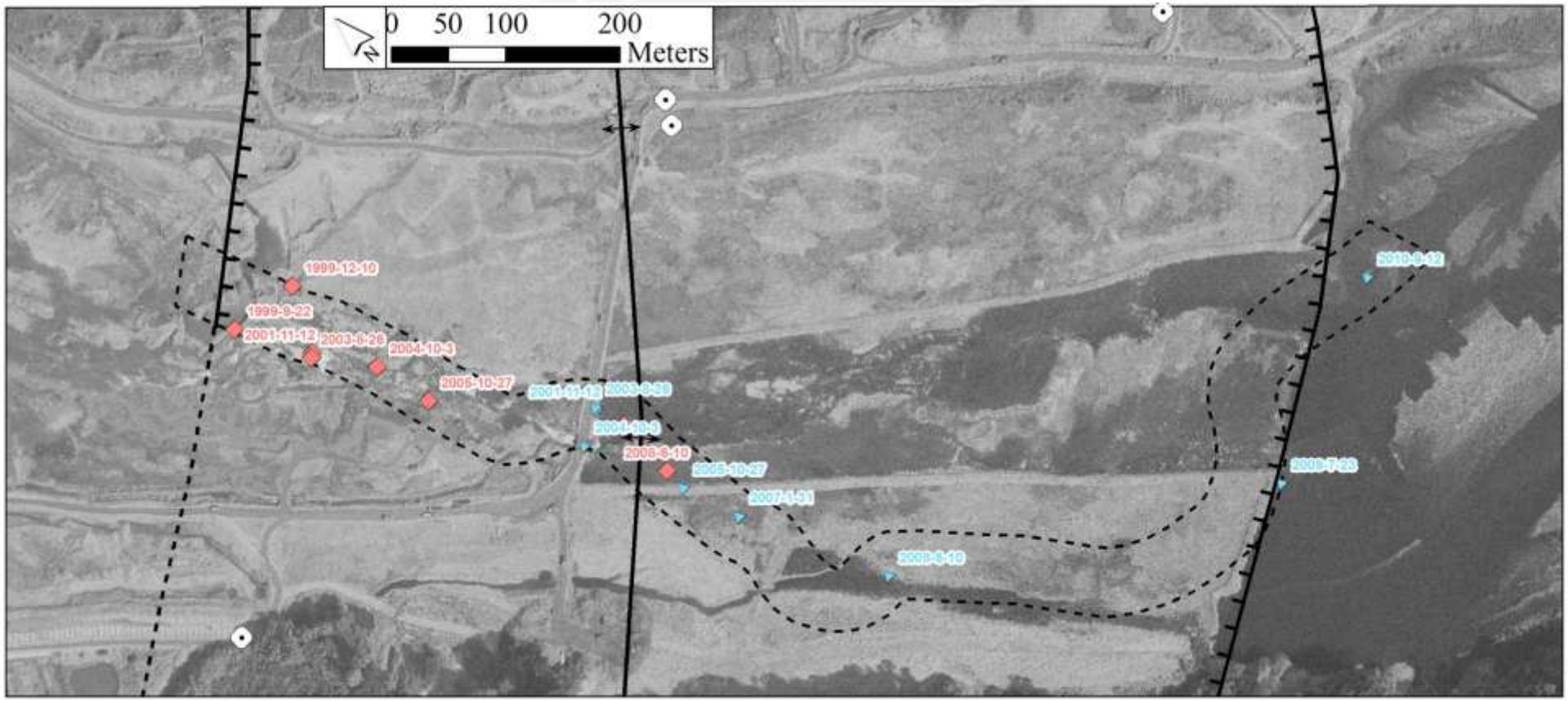
1999-12-10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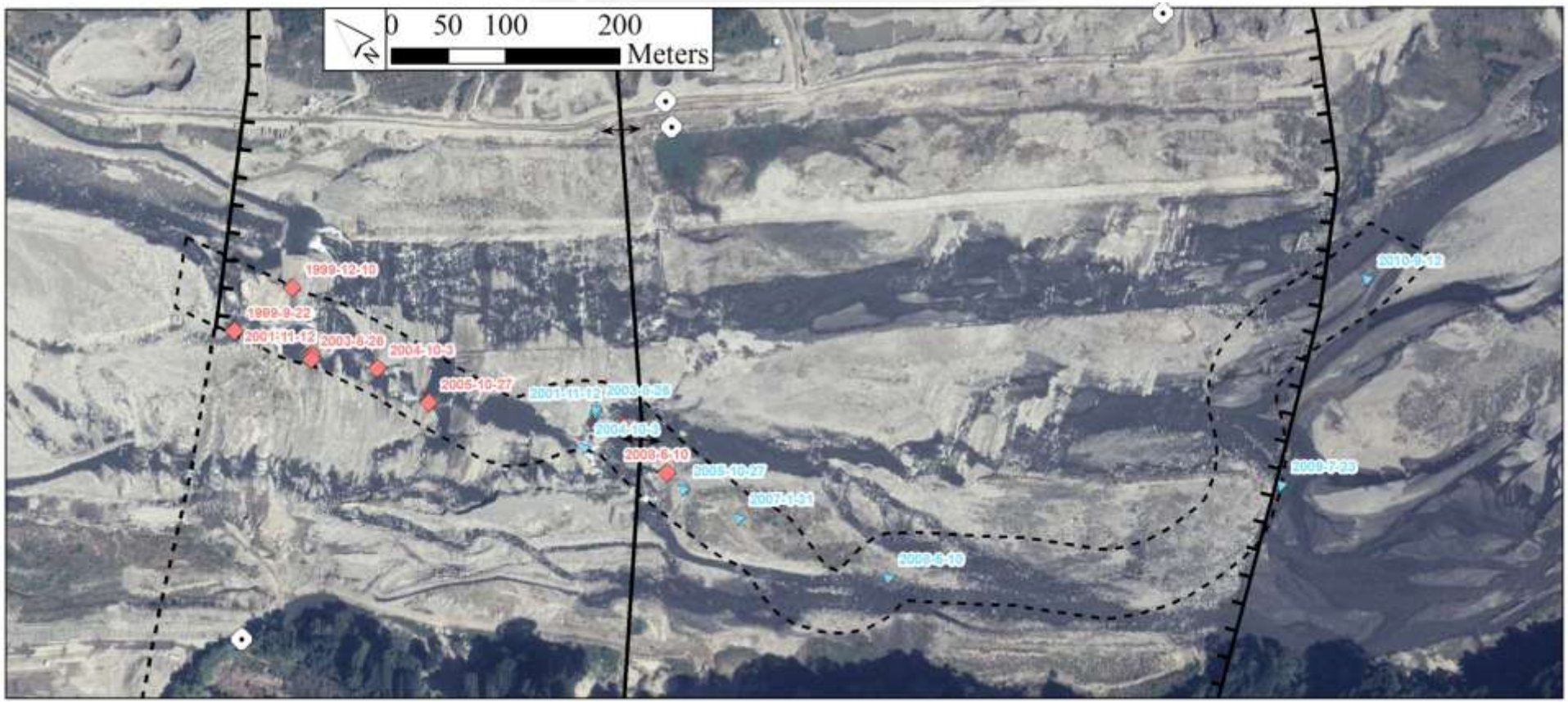
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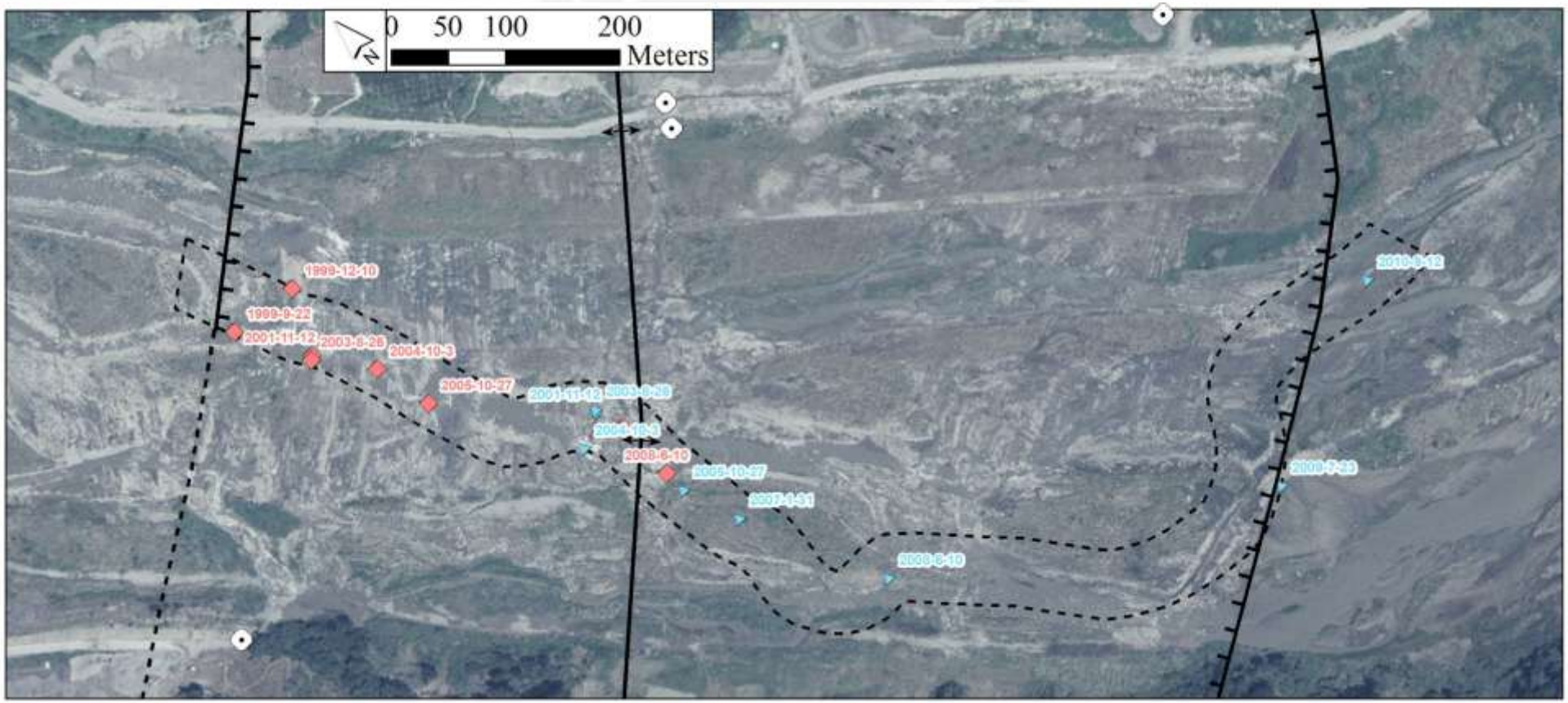
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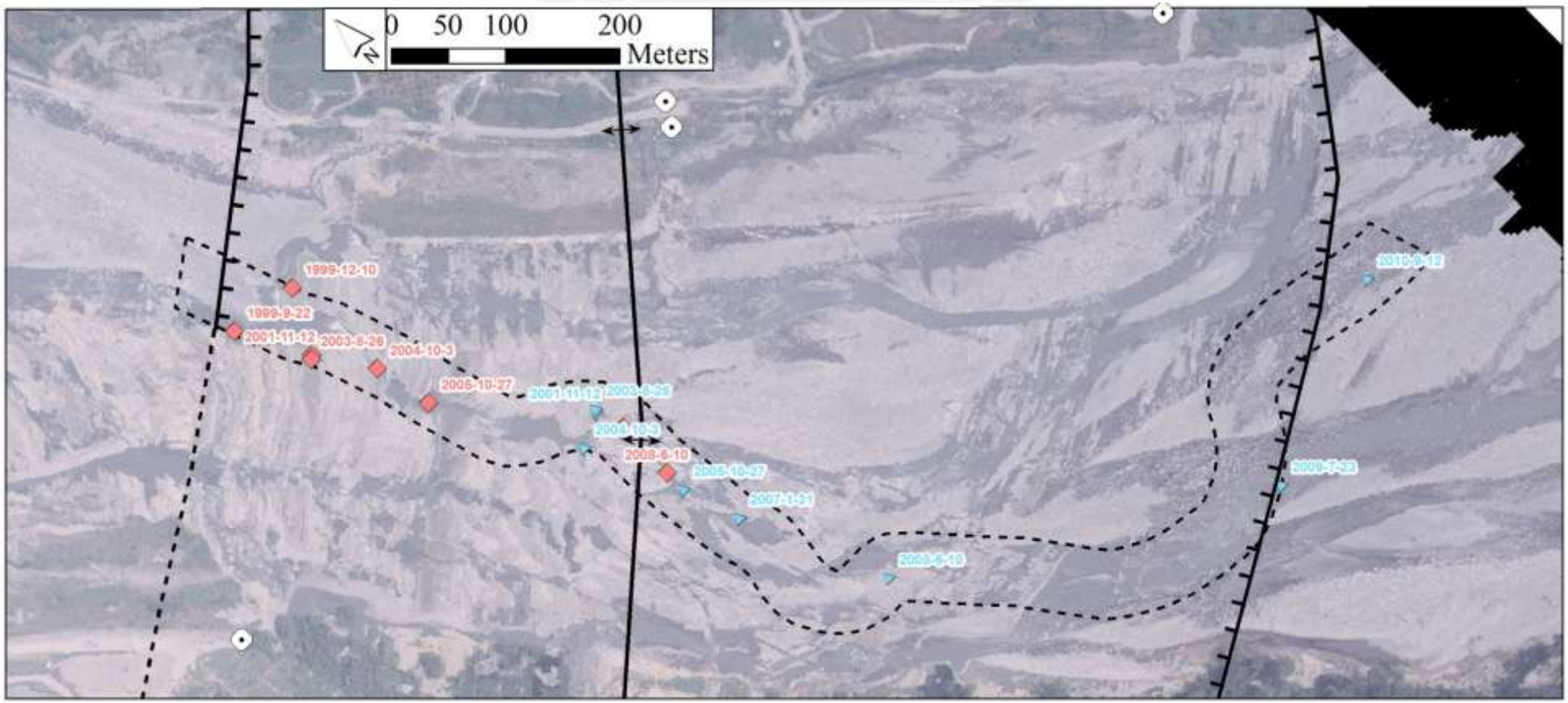
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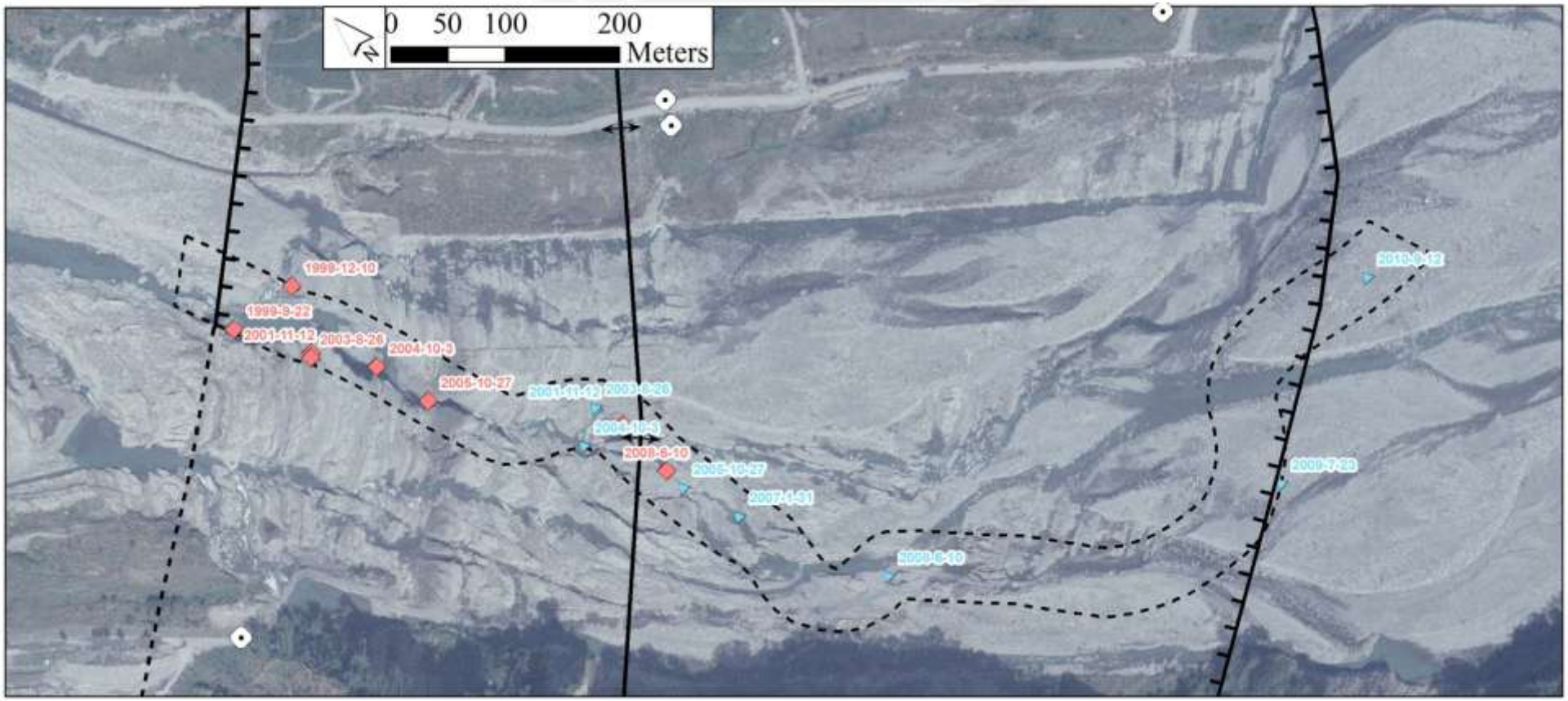
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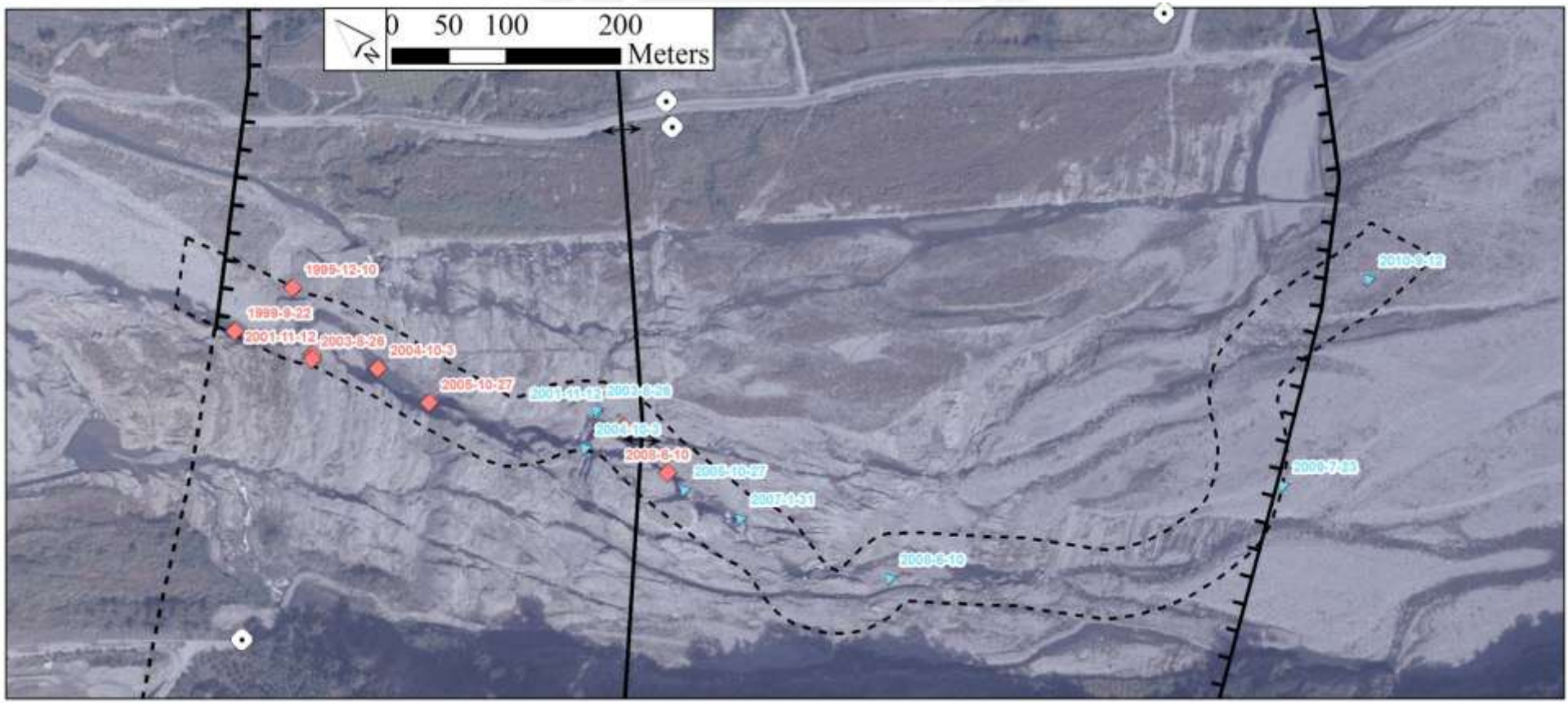
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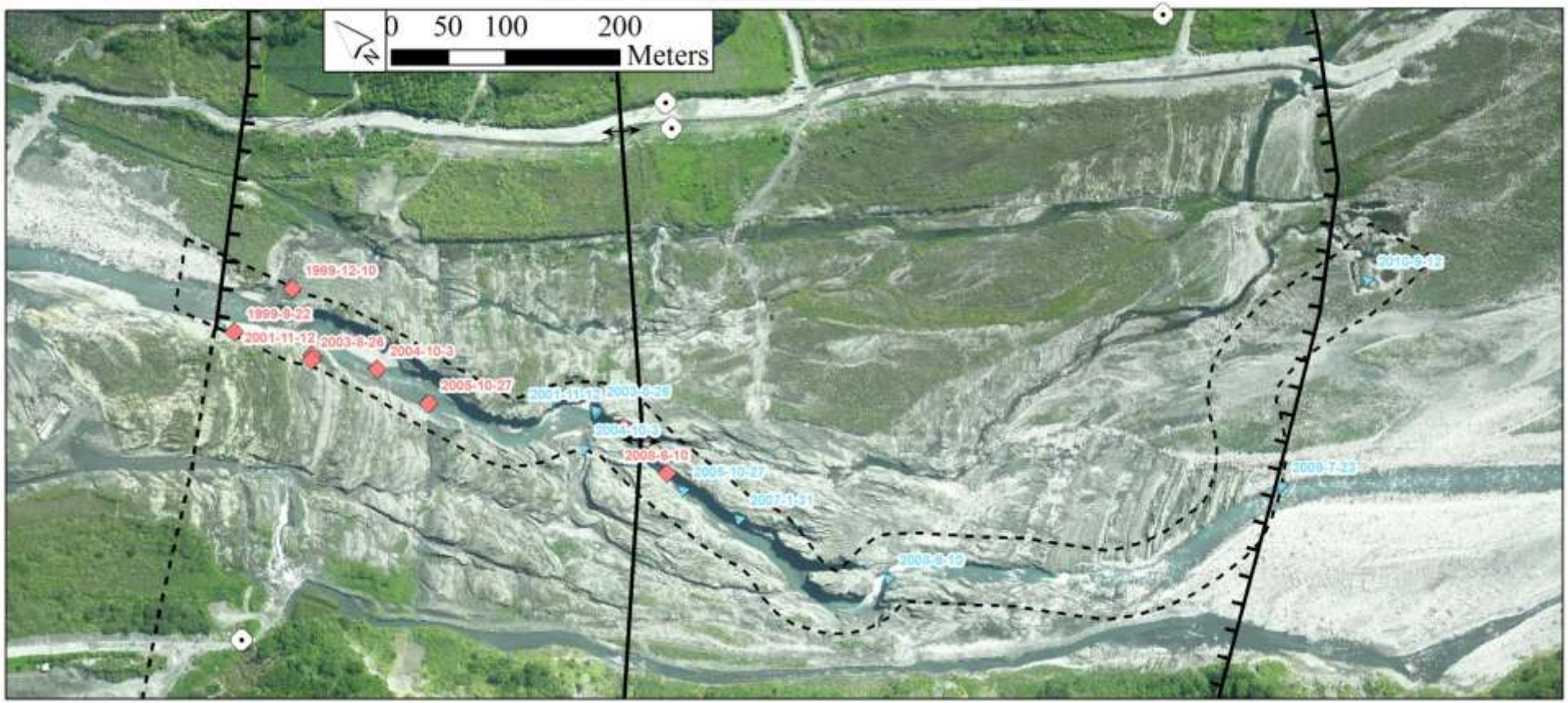
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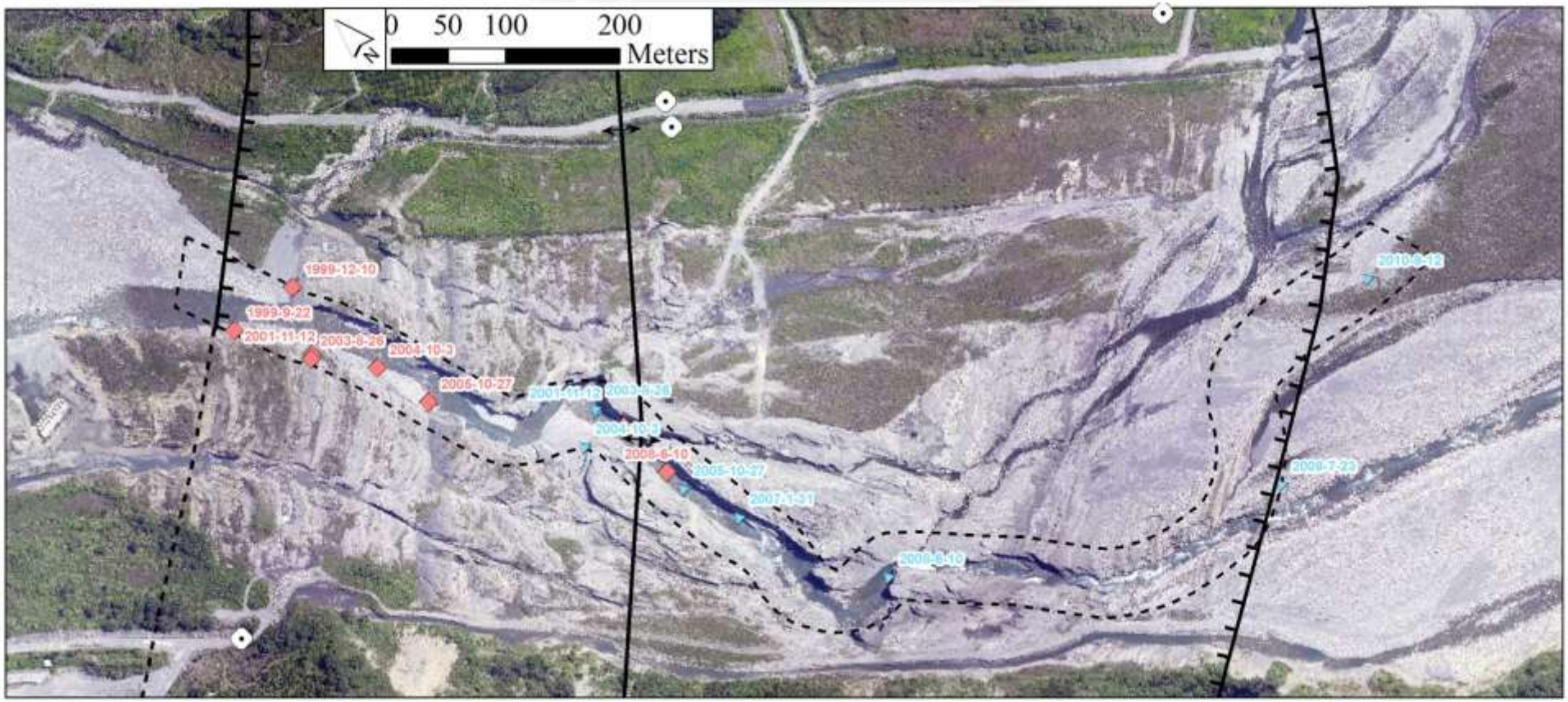
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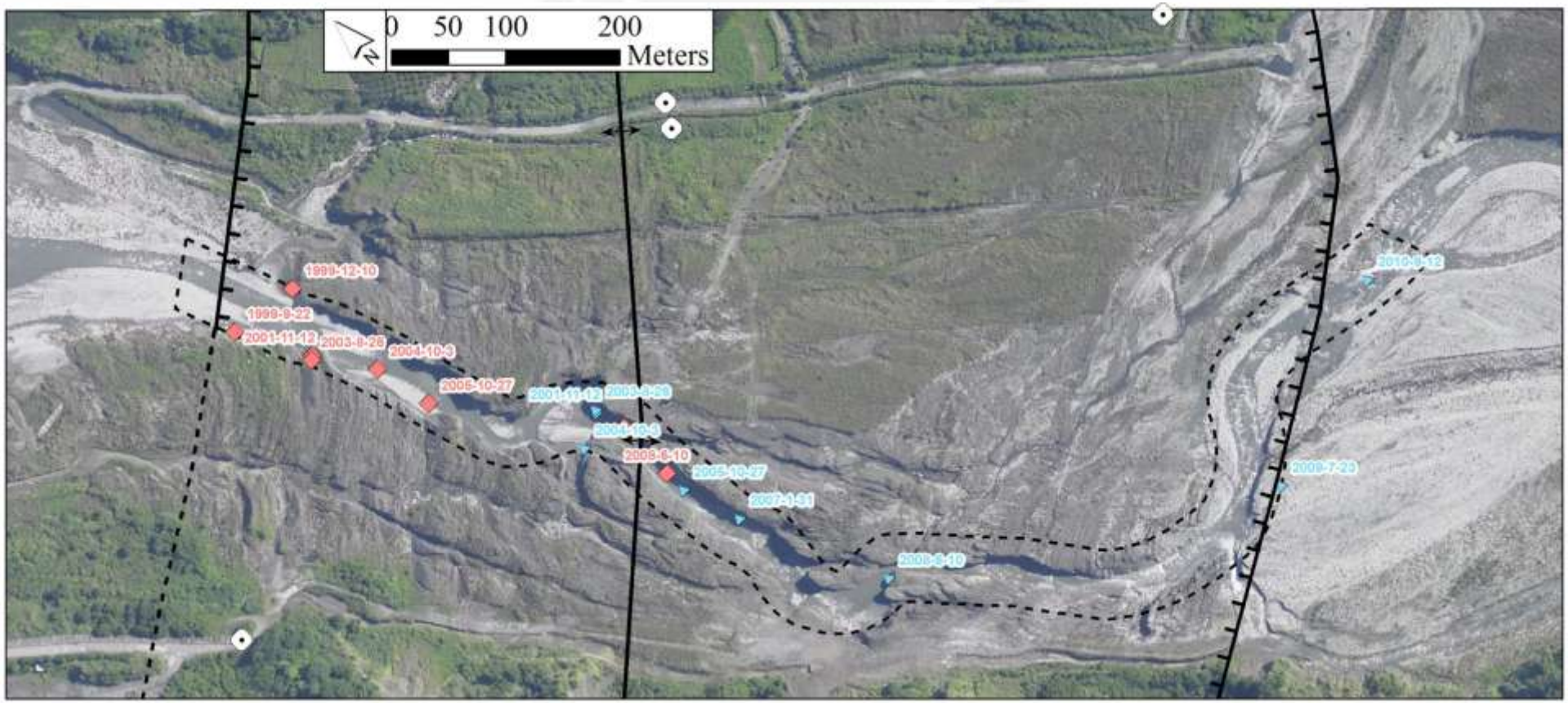
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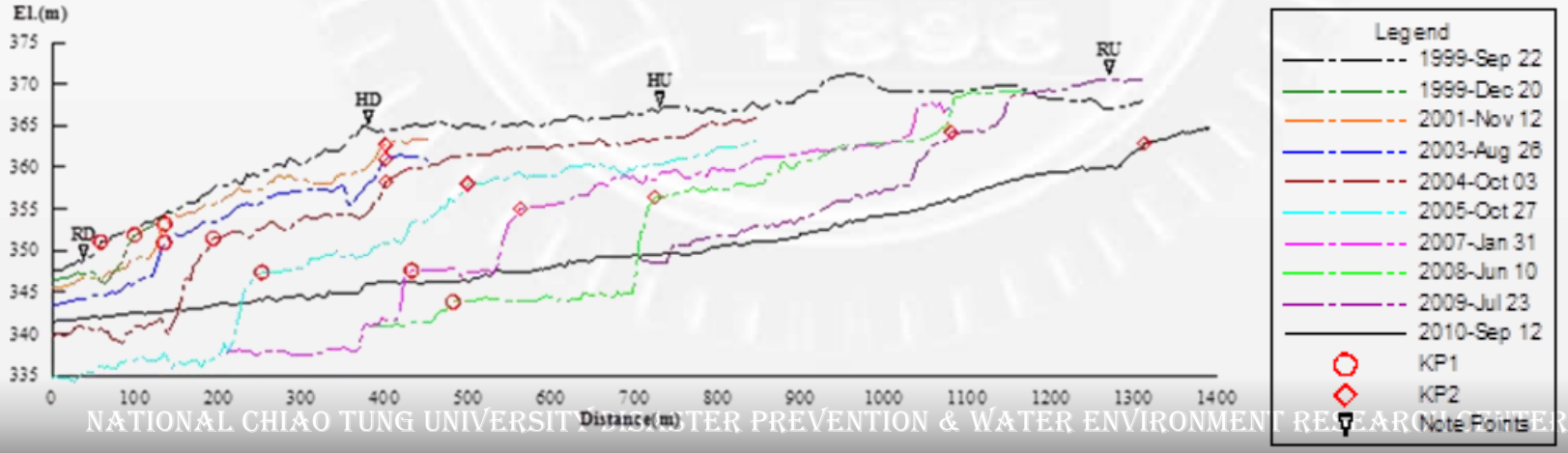
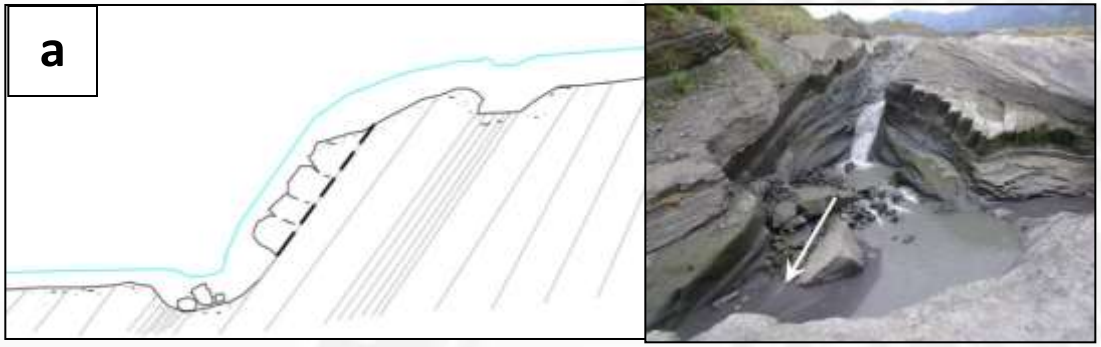
2009-7-28
2010-9-12

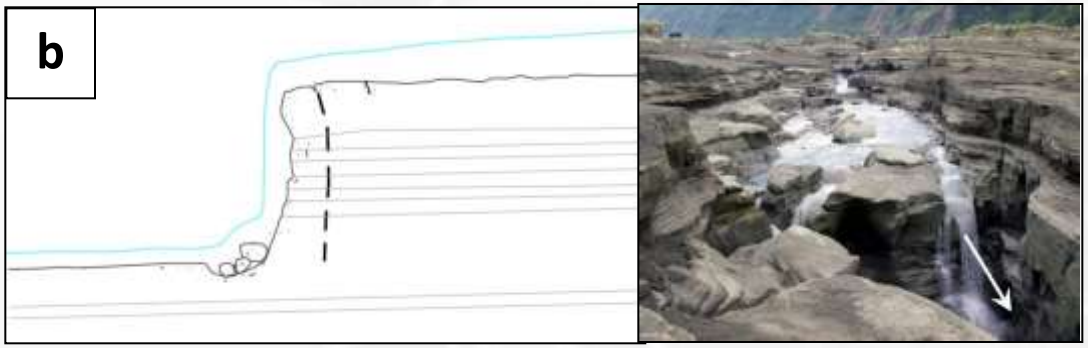
Discussion—KP retreatment

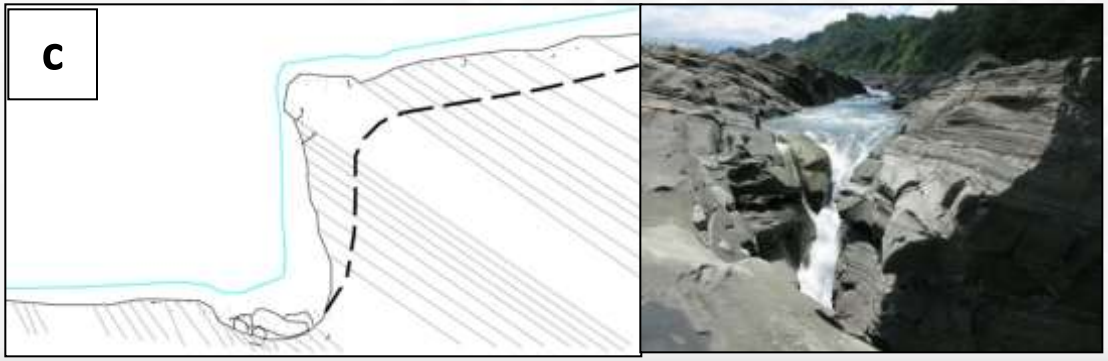
time interval	knickpoint 1		note	knickpoint 2		note
	retreat distance(m)	vertical incision(m)		retreat distance(m)	vertical incision(m)	
1999-Sep 22 to 1999-Dec 20	40.5	4.7	alluvial	-	-	
1999-Dec 20 to 2001-Nov 12	36.0	2.8	alluvial	-	-	
2001-Nov 12 to 2003-Aug 26	0.0	2.2	dipping downstream	0.0	1.7	horizontal bedding
2003-Aug 26 to 2004-Oct 03	58.5	10.2	dipping downstream	0.0	2.7	horizontal bedding
2004-Oct 03 to 2005-Oct 27	58.5	**14.4**	dipping downstream	99.0	7.4	horizontal bedding
2005-Oct 27 to 2007-Jan 31	180.0	9.4	dipping downstream	63.0	10.6	horizontal bedding
2007-Jan 31 to 2008-Jun 10	49.5	6.2	horizontal bedding	162.0	11.2	horizontal bedding
2008-Jun 10 to 2009-Jul 23	vanished	sediment deposited	alluvial	**355.5**	7.8	dipping upstream
2009-Jul 23 to 2010-Sep 12	-	-	alluvial	232.0	8.1	dipping upstream



Three knickpoint types







(a) Dipping upstream
- Scour hole
- Water seeps into bedding planes
- Plane sliding

(b) Horizontal bedrock
- Scour hole
- Seepage in the tensile cracks
- Cut down bedrock

(c) Dipping upstream
- Scour hole
- Overhanging rock blocks fall

Conclusion

- Exceptionally case of rapid change in river morphology
  - The annual migration rate was tens of meters even up to 355 m
  - The annual incision rate was meters even up to 14 m/year
- Extremely high rates of knickpoint retreat and vertical incision were responsible for the rapid morphology evolution
- The flow tends to undercut the rock layer in front of the knickpoint before significant retreat starts
- The instability of rock mass in the steep slope adjacent to the knickpoint may explain why the knickpoint retreat rate and incision rate are so high
- Three mechanisms of slope instability associated with different types of knickpoint migration were identified

Thank you